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NATIONAL RESEARCH COUNCIL

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Committee on American forest research,

NORTH AMERICAN FOREST RESEARCH

Investigative Projects in Forestry and Allied Subjects Conducted by National, State, and Provincial Governments, Schools of Forestry, Scientific Schools, and Private Interests in Canada, Newfoundland, and the United States for 1919–1920

Compiled by the Committee on American Forest Research, Society of American Foresters

Earle H. Clapp, Chairman, Clyde Leavitt, Walter Mulford
J. W. Toumey, E. A. Ziegler

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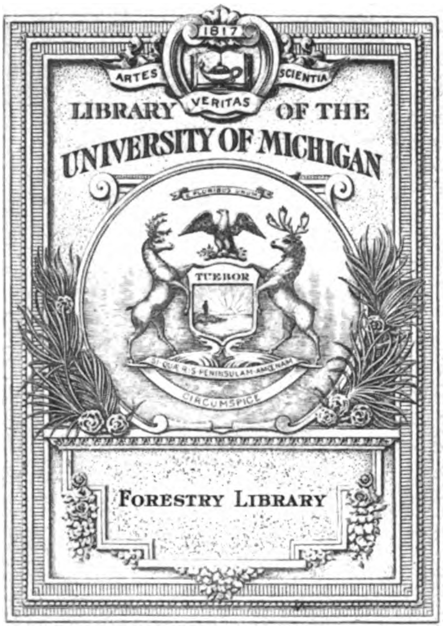

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INTRODUCTION

Although forest research in North America is still very young, some distinct advance has already been made. Twenty years ago there were no foresters trained in American schools. To-day there are approximately 1500 trained foresters, graduates of technical schools of high standing, many of whom are devoting their efforts to forest research. The beginning of systematic forest research dates from the establishment of the Forest Products Laboratory at Madison, Wis., in 1909, of the Forest Products Laboratories of Canada at Montreal in 1915, and of the several forest experiment stations on the National Forests of the West, the first of which was established at Flagstaff, Arizona, in 1908.

Since this beginning, the increase in the number of agencies engaged in forest research and in the scope and intensity of the studies undertaken has been a promising indication of the growing need for adequate information along these lines. Not including the Federal departments of Canada, Newfoundland, and the United States, there are now from 40 to 50 state, provincial, college, and corporate organizations, and individuals engaged in the study of problems in forestry and related subjects.

Some 520 projects are now being conducted by various agencies in the United States, Canada, and Newfoundland. In view of the volume of work now being carried on, the Research Committee of the Society of American Foresters felt the need for some clearing-house of information on the current investigative projects. This program represents, therefore, an attempt to bring together the projects on which forest investigators are engaged in North America. It is hoped that it may be a means of informing the different investigators of the work of each other and in this way help indirectly to avoid duplication of effort and give the encouragement that must come from the knowledge that there are others who are working within the same field.

The Committee desires to express its appreciation of the hearty response to its requests for cooperation. To those of the contributors whose statements had to be revised in form or volume, and to any investigators who may have been overlooked by this

Committee in its requests (it is realized that some such omissions may quite naturally have occurred in this first review of the field) it offers its apologies. It is further appreciated that for certain organizations the projects may not in all cases have been finally approved. They are included in the form reached.at the time of compilation. Furthermore, the programs of many organizations were affected by the war and the still in a more or less unsettled state. In future editions of the program any such omissions an any errors which may have crept into this issue may be corrected. To this end the Committee earnestly desires the fullest criticism of its initial work and solicits suggestions of every kind as to the continuation of the program and improvements which may be incorporated in it.

The publication and distribution of this program was made possible only through the kindness of the National Research Council, to which the Committee acknowledges its gratitude. The Committee desires to acknowledge its obligation to Mr. Earl H. Frothingham, of the U. S. Forest Service, who performed practically the entire task of compilation.

DOMINION OF CANADA

DOMINION FORESTRY BRANCH

R. H. Campbell, Director of Forestry, Ottawa

PETAWAWA FOREST EXPERIMENT STATION, Petawawa, Ontario

1. **Forest survey.** To obtain detailed information in regard to the various species and forest types, soil, site-classes, age classes and their distribution, quantity and quality of timber and reproduction, etc. Area examined 100 square miles.

Work begun in August, 1917. Preliminary report submitted. Survey completed 1919.

Working plan to be prepared.

Assigned to Forest Survey Staff.

2. **Thinnings.** Effects on remaining stand, individual trees, soil, and ground cover, of thinnings of different degrees and methods.

Work begun in 1918. Studies on permanent sample plots in stands of jack pine and in white pine and red pine with intermingled white spruce, white birch, red maple, aspen, and other hardwoods now under way. Plots accurately mapped showing exact position and size of trees thinned out and of remaining trees.

To be continued and extended to other types.

Assigned to Head Office Staff, Ottawa.

3. **Reproduction studies.**

Work begun in 1918. Reproduction on old and recent burns studied on sample plots. Permanent sample plots also laid out to study reproduction of coniferous species in stands of *Betula alba papyrifera*. Reproduction studies in hardwood stands.

To be continued and extended, and forest conversion experiments to be undertaken.

Assigned to Head Office Staff, Ottawa.

4. **Yield tables.**

Work begun in 1918. Sample plots laid out for the study of yield in pure white pine, pure jack pine, and pure red pine stands.

To be continued and extended to other types.

Assigned to Head Office Staff, Ottawa.

5. **Stemform and taper of trees.**

Work begun in 1918. A study of stemform of white pine and red pine, using Prof. Tor Jonson's absolute form quotient as an expression of form or taper to verify or otherwise the application of this form quotient as a true expression of form or taper. The evidence is not sufficient in quantity to finally establish the applicability of Jonson's theories on white and red pine, but so far as it has been gone into, it all points to the conclusion that the absolute form quotient is an excellent expression of form and that if the absolute form quotient is known the taper of the tree in all other parts can be determined. Preliminary report submitted. The 1919 researches show that Jonson's theories are applicable.

This study is to be continued, and it is hoped that it will lead to the preparation of universal volume and taper tables based on diameter, total height, and form class.

Assigned to Head Office Staff, Ottawa.

TREE PLANTING DIVISION, Indian Head, Saskatchewan

Nursery practice

6. **Propagation of box elder as 1-year seedlings; caragana as 1-year seedlings; green ash as 2-year seedlings.**

Methods of sowing and cultivation well established. Can hardly be called research work now.

7. **Propagation of willow and poplars from cutting stock.**

8. **Propagation from seed and transplanting of Scotch pine, jack pine, and white spruce.**

Methods well established.

Artificial reproduction on forest reserves

9. **To determine varieties best suited to different conditions of soil and different localities.**

10. **Investigating by experiment on fairly large scale method of direct sowing of pine and spruce on sandy soils.**

11. **Planting out of seedlings and transplants of pine and spruce to determine best methods of planting under different conditions of soil and soil cover and best ages of plants.**

Trials on the nursery station

12. **In connection with hardiness**; several varieties are under test at present.

13. **Rates of growth of varieties under cultivation,** on the ordinary upland prairie soils, under conditions similar to those obtaining in average farm shelter belts and plantations. Species under investigation: box-elder, green ash, American elm, white birch, cottonwood, Russian poplars, willows, Scotch pine, jack pine, lodgepole pine, white spruce, Colorado spruce, Norway spruce, tamarack, European larch, Siberian larch.

Examinations of farmers' plantations

14. **To study comparison of growths in different locations and districts.**

15. **Effect of original preparations of soil on subsequent development.**

16. **Effects of cultivation on later developments of plantations.**

17. **Effects of spacing.**

18. **Extent to which grass and weeds influence the growth.**

19. **Behavior of different varieties in different mixtures.**

20. **Comparison of hardiness of same varieties in different districts.**

FOREST PRODUCTS LABORATORIES OF CANADA, **Montreal, Quebec**

21. **Mechanical, physical, and structural properties of woods grown in the Dominion of Canada,** based on tests of small clear specimens.

(*a*) Three shipments of Douglas fir tested. Results of tests published as Canadian Forestry Branch Bulletin 60. (*b*) One shipment each of black spruce, white spruce, Sitka spruce, white pine, and red pine tested, also two other shipments of Sitka spruce. (*c*) Work in progress on three shipments of western hemlock, two of yellow birch, two of sugar maple, and one shipment each of red spruce and eastern hemlock.

Work to be continued on other eastern and western Canadian species.

Assigned to Division of Timber Tests (Montreal) and Vancouver Branch Laboratory, Vancouver, B. C.

22. **Strength functions and physical properties of Nova Scotia mine timbers.**

(*a*) Tests completed on full-sized pit timbers of five different species. Both green and air-dried timbers tested in compression and bending. Results not yet published in printed form. (*b*) A species not previously used for mine timbers in Nova Scotia has been shown by the tests to be suitable for this purpose and has been successfully substituted for standard species by at least one company.

Bulletin to be prepared formally presenting the results of this investigation.

Assigned to Division of Timber Tests.

23. **Utilization of waste sulphite liquor (bibliography).**

Literature of the world reviewed. Publication issued as Canadian Forestry Branch Bulletin 66, in May, 1919.

Appendix to be added every two or three years.
Assigned to Division of Pulp and Paper.

24. **The beating of paper pulp.**
Preliminary work on motor tests and control apparatus partially completed.
Investigations to be continued when facilities are available.
Assigned to Division of Pulp and Paper.

25. **Chemistry of wood.** (*a*) Study of methods of analysis; (*b*) analysis of wood; (*c*) study of resins.
Study of methods of determination of cellulose completed and published. Analyses of five native species partially completed. Study of resins in same five species partially completed.
Analyses of wood and of resins to be continued.
Assigned to Division of Pulp and Paper.

26. **Australian woods for pulp**—*Eucalyptus rubida.*
Chemical and physical analysis of wood completed and submitted as Progress Report No. 1.
Project to be completed when facilities are available.
Assigned to Division of Pulp and Paper.

27. **Relative durability of Canadian commercial woods.**
Series of fungus bed tests, undertaken to test suitability of this method, completed.
Work on methods to be continued.
Assigned to Division of Timber Physics.

28. **Fiber measurements of Canadian woods.**
Work completed on eight species of conifers. Results on one species published; those on other seven being prepared for publication.
Investigation to be extended to other species.
Assigned to Division of Timber Physics.

29. **Preparation of reference collection of wood section slides of Canadian and other woods and study of anatomy of these woods.**
Slides prepared for a number of species. Study of anatomical features proceeding. Photomicrographs at different magnifications prepared.
Preparation of slides and study of various features of anatomy to be continued.
Assigned to Division of Timber Physics.

30. **Railway ties—Section 1.** Experimental treatment of jack pine and hemlock ties.
(*a*) Study of creosote treatment of jack pine and hemlock ties completed. Results reported in Canadian Forestry Branch Bulletin 67, "Creosote Treatment of Jack Pine and Eastern Hemlock for Cross Ties." Patents on process developed in the course of this work pending. (*b*) Seasoning study and creosote treatment of jack pine and hemlock ties for service tests have been undertaken.
Work on No. 2 to be completed.
Assigned to Division of Wood Preservation.

31. **Paving blocks.** Experimental investigation of some important factors in the creosote treatment of red pine paving blocks.
Effects of different preservatives and treatments on swelling and bleeding of the blocks are being investigated.

Work on bleeding and swelling tests to be continued.

Assigned to Division of Wood Preservation.

32. **Fence posts—Section 1.** Experimental creosote treatment of Russian poplar posts for service tests.

Posts have been treated and installed and yearly inspections are being made.

Reports of yearly inspections to be compiled and conclusions drawn.

Assigned to Division of Wood Preservation.

33. **Field survey of railroad ties.**

Study of Canadian conditions and ties in track proceeding.

Study to be completed and results compiled—to serve as a basis for research.

Assigned to Division of Wood Preservation.

34. **Field survey of timber exposed to influences favorable to its decay.**

Study of the following is proceeding: (*a*) decay of timber in buildings and structures; (*b*) decay of pulpwood in storage piles; (*c*) deterioration of stored groundwood pulp. Several articles bearing on (*a*) have been published in trade or technical journals.

To be continued and further matter to be prepared for publication.

Assigned to Pathologist, Division of Timber Physics.

COMMISSION OF CONSERVATION, Ottawa, Canada

CLYDE LEAVITT, Chief Forester

35. **Forest regeneration survey.** To determine the nature and amount of regeneration on cut-over pulpwood lands; the rate of growth of the commercial species on such lands. General reconnaissance, strip surveys, growth studies.

Begun in 1917 in cooperation with the Laurentide Company, Grand'-Mère, Quebec. Cooperation with the Riordon Pulp and Paper Company, Montreal, 1918, and with the Abitibi Power and Paper Co., Montreal, 1919 (limits in Ontario); collaboration with the New Brunswick Forest Service, 1918 and 1919.

Continuance with the present coöperators and extension to others as opportunity offers. Application of the same kind of investigation to burned-over lands.

Assigned to Dr. C. D. Howe in charge (Commission of Conservation of Canada). Field work in Quebec, Ontario and New Brunswick.

36. **Forest sample plot studies.** To make a detailed record of changing conditions through a series of years on permanent sample plots; to ascertain the influence of insect and fungus diseases in determining the composition of the forest and their influence upon the decay of slash; to study the factors which influence the regeneration and the rate of growth of the commercial species.

Three one-acre plots established on limits of the Laurentide Company and one on the limits of the Riordon Pulp and Paper Company in 1918. In 1919 there were established thirteen one-acre permanent sample plots on limits of the Laurentide Company, in addition to 160 acres of experimental cuttings; six one-acre sample plots on Riordon Company limits (Quebec); and 250 acres of experimental cuttings on Bathurst Lumber Company limits (New Brunswick); these are in cooperation with the respective companies and with the New Brunswick Forest Service, as to work in that Province.*

To be continued with present cooperators and extended to others as opportunity offers.

Dr. C. D. Howe, forestry, Dr. W. H. Rankin, fungi (Commission of Conservation of Canada). Dr. J. M. Swaine, insects (Dominion Entomological Branch, Department of Agriculture, Canada).

DEPARTMENT OF AGRICULTURE, Ottawa, Canada

Entomological Branch

Division of Forest Insects

J. M. SWAINE, Chief of Division

37. Bark-beetle injuries in British Columbia. Injuries to the yellow pine, with emphasis on control of present serious infestation.

Investigations of these beetles, their habits and effective control measures, have been carried on since 1913; results summarized in several publications, chiefly in Bulletins 7 and 14 of the Dominion Entomological Branch.

Further work to include organization and supervision of control measures. Modified logging operations to be employed where feasible. Special effort to be made to check spread of present serious infestation. Further investigations to be made of important bark-beetle outbreaks in other western conifers, with organization of control measures where feasible.

Assigned to J. M. Swaine and Ralph Hopping, in charge of forest insect investigations in British Columbia.

38. Biology of Canadian bark-beetles.

A detailed study of the life history and habits of bark-beetles has been in progress since 1912, leading to development of methods of control, where needed.

Continuing.

Assigned to J. M. Swaine and Ralph Hopping.

39. Classification of North American bark-beetles.

Under way since 1912. Part of the results published in articles in the "Canadian Entomologist" and in Bulletins 7 and 14 of the Dominion Entomological Branch. Studies of immature forms in progress. Extensive collections from Europe and northern Asia have been obtained.

It is planned to continue this study, extending its scope to cover the fauna of Europe and northern Asia.

Assigned to J. M. Swaine.

40. The balsam injury of eastern Canada.

Has been carefully studied for several years. Studies of the injury and the factors involved are in progress in parts of Quebec and New Brunswick. Results point to slash burning as a necessary practice in eastern Canada. Publication: Agricultural Gazette of Canada, Vol. 6, No. 3, March, 1919.

Further studies planned for next season.

Assigned to J. M. Swaine, S. A. Graham, M. B. Dunn, in cooperation with J. D. Tothill in New Brunswick.

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* (See also under Dominion Department of Agriculture, Entomological Branch, Forest sample plot studies.)

41. **Forest sample plot studies.** To determine the part taken by insects in the development of a stand of balsam under various conditions.

Permanent sample plots were laid out in 1918 at two stations in the Laurentians, and others are being established this summer in young balsam stands in different watersheds in Quebec Province and in New Brunswick. Trees numbered and described. Publication: Agricultural Gazette of Canada, Vol. 5, No. 9, p. 860, 1919. (See also under Dominion Commission of Conservation, Forest sample plot studies.)

Trees to be examined each season for insect injuries. It is planned to make these sample plots an important branch of the work, covering eventually all Canadian timber trees under different local conditions. Each group of sample plots will be a forest insect field station, in operation part or all of each summer.

Assigned to M. B. Dunn and other officers, in cooperation with the Commission of Conservation and the lumber companies on whose lands the plots are located.

42. **Larvae of wood-boring beetles.**

Studies have been undertaken in cooperation with biologic studies of wood-boring species.

Continuing.

Assigned to R. N. Chrystal.

43. **Studies with the genus** *Chermes* (spruce gall aphides).

Investigation of biology and control of these important enemies of spruce shade trees was in progress during 1914 and 1915, and is being continued this season.

Continuing.

Assigned to R. N. Chrystal.

44. **Borers in shade trees.**

Detailed studies of the biology and control of such important shade tree enemies as the bronze birch borer, the locust borer, and the carpenter worms of the genus *Prionoxystus* have been in progress for two seasons.

Continuing.

Assigned to C. B. Hutchings.

45. **Relation of weather phenomena to activities of forest insects.**

Under way.

Continuing.

C. B. Hutchings in cooperation with officer in charge of Natural Control Investigations.

46. **Life histories of forest insects.**

A field laboratory is maintained during the summer near Fort Coulonge, P. Q., for the study of forest insect biology. Special attention is paid to the families *Cerambycidae* and *Buprestidae*.

Continuing.

All officers of the Division; Laboratory in charge of J. I. Beaulne.

47. **Shade tree insect investigations.**

Attention is paid to the more important insect injuries to shade trees as they develop.

Continuing.

Officers of the Division.

BRITISH COLUMBIA

Department of Lands, Forest Branch, Victoria

M. A. Grainger, Chief Forester, Victoria

48. Combating insect damage to western yellow pine.

The danger of the total destruction of the stands of western yellow pine in the interior of the Province by Dendroctonus beetles has attracted attention for some years. Lately it has resulted in an active campaign of remedial measures.

The campaign of cutting the infected timber and destroying the broods is to be continued.

Assigned to Major Andrews and the local forestry officials in cooperation with Mr. Hopping of the Department of Agriculture, Division of Forest Insects, in charge of control measures.

49. Reproduction studies.

In 1914 in cooperation with the Commission of Conservation a study was made by Dr. C. D. Howe, and a report entitled "The Reproduction of Commercial Species in the Southern Coastal Forest of British Columbia" was published.

It is planned to make studies on timber sale areas to determine whether or not reproduction is adequate and of the right species, and if not, why not; and the best way to correct the defect. Brush disposal methods in their relation to reproduction will be studied. Permanent sample plots are also to be established.

Assigned to F. McVickar.

50. Volume tables.

Work was started on the coast in 1913 and 1914, and tables made for fir, hemlock, and cedar. In the interior work was carried on from time to time as circumstances permitted.

Existing data are being checked over, with a view to securing measurements for species in the regions where not already sufficient.

Assigned to F. McVickar.

51. Range of British Columbia trees.

In 1913 and 1914 maps were made showing the range of each tree species in British Columbia.

These maps will be sent out to the Forest Districts for revision by the men in the field.

Assigned to Field Staff.

52. Grazing.

The Grazing Commissioner, after a good deal of study and discussion with the ranchers, has divided the country into grazing districts, and has drawn up a series of grazing regulations.

Studies to be continued. Regulated grazing and cooperation with the Forest Branch in grazing matters to be further developed.

Assigned to T. P. McKenzie, Grazing Commissioner, and Grazing Assistant Copley.

53. Timber testing.

Last year a small forest products laboratory was established at the University of British Columbia. It is the purpose of this laboratory to attend to local problems in timber physics and wood utilization.

The work just begun is to be continued and extended.

Assigned to Forest Products Laboratory, University of British Columbia, Vancouver.

54. Forest resources of British Columbia.

The Commission of Conservation has been in cooperation with the Forest Branch in an investigation of British Columbia's resources. The results have been published in "Forests of British Columbia," by H. N. Whitford, Ph.D., and Roland D. Craig, F.E., Commission of Conservation, Ottawa, Canada, 1918.

This subject will be kept constantly in mind, and from time to time more accurate details will come up so that it is hoped in future to have a more extensive and accurate knowledge of this subject.

Assigned to The Staff.

55. Study of the growth of timber and preparation of yield tables as a basis for sustained yield management of Crown timber lands.

A certain amount of growth studies have been made from time to time; but have not been intensive enough to serve as a basis for working plans.

Intensive growth studies to be made and yield tables prepared, on certain areas of land unsuited to agriculture but well suited for timber crops.

Assigned to Staff of Assistants under direction of Major Andrews.

COMMERCIAL ORGANIZATIONS, CANADA

Abitibi Power and Paper Company, Limited, Iroquois Falls, Ontario

H. G. SCHANCHE, JR., Chief Forester

56. Regeneration survey. Carried on upon virgin and cut-over areas on the Company's holdings to secure data on the reproduction, its composition, amount, rate of growth, effect of logging methods in vogue.

Field work commenced May 15, 1919. Season's field work completed on September 20, 1919. Computation and working up of field data in progress January, 1920. (See also under Dominion Commission of Conservation, Forest regeneration survey.)

Field work to be continued during summer of 1920 in vicinity of Lake Abitibi.

Past work carried on jointly by Commission of Conservation and Forestry Department of the A. P. & P. Co. Work under direction of C. D. Howe, Ph.D., Forestry Faculty, University of Toronto. Same cooperative methods to be employed in 1920.

57. Growth studies. Complete tree analyses of 500 trees each of white spruce, black spruce, and balsam, of all diameter classes occurring in vicinity of Lake Abitibi, to ascertain rates of growth of the three species in specified regions and secure foundational data for compilation of volume tables.

Field work commenced Nov. 18, 1919, and was suspended Dec. 20, 1919. Compilation of data secured in the field in progress January, 1920.

Field work to be continued in fall of 1920.

Assigned to Forestry Department of the A. P. & P. Co., in conjunction with Forester of Commission of Conservation Staff.

58. Nursery experiments. A large quantity of coniferous species exotic to northeastern Canada will be introduced in the nursery operations to ascertain which species may thrive and develop under local conditions; comparisons will be drawn between progress in development under local conditions, and progress made within the natural range.

Experiments to commence with the beginning of nursery operations in the spring of 1920.

Experiments to be carried on until definite conclusions shall have been reached.

Assigned to Superintendent of Nursery, Forestry Department A. P. & P. Co.

Laurentide Company, Limited, Grand' Mère, Quebec

Ellwood Wilson, Manager Forestry Division

59. **Brush disposal.** Methods and cost to determine best way from standpoint of reproduction and fire risk.

Work begun in 1913. Toplopping done in that year and examination since to determine time of rotting of lopped and unlopped tops. In 1917 began burning brush. Costs kept and work continued until present.

Examination of areas lopped and burnt will be continued and each operation will have brush burned.

Assigned to Forester in charge and local force.

60. **Thinning.** Effect of different degrees of thinning on planted spruce and pine.

Work begun in 1913 and continued to date. Plantations made under poplar and birch and also under hardwood. Acre plots laid out and permanently marked.

Work to be continued and number of plots increased.

Assigned to Forester in charge and local force.

61. **Nursery practice and planting.** Experiments in new technique in planting, cultivating, and transplanting. Fall and spring seeding and planting. Amounts of water and shade. Comparisons between trees dominant and suppressed from seed in nurseries and in field planting. Sample plots laid out where such dominants and suppressed trees are planted side by side on different slopes and aspects. Experiments with different fertilizers and soils.

Nursery started in 1909. Now contains 42 acres.

Work will be continued as outlined.

Assigned to Forester in charge and local force.

62. **Fire protection.** Use of seaplanes for fire protection.

Two seaplanes with 400 H. P. Liberty engines began work June 28, 1919.

Planes will fly every day when there is no rain or fog, to locate, report, and if possible extinguish forest fires.

Assigned to Pilot in charge and personnel.

63. **Mapping.** Test of aerial photography for mapping forest areas. Mosaic maps to be made from photographs at different altitudes. Cost data to be compiled. Will map 3000 square miles, 1920. Make progress maps of river drives.

Two seaplanes working.

Assigned to Pilot in charge and personnel.

64. Lumbering studies. To get lumbering costs under different conditions and to try to improve methods and machinery.

Work commenced in 1908 and continued. Work since 1917 on clearing lands for planting, marketing firewood, ties, telephone poles, fence posts, and lumber.

Work will be continued.

Assigned to Forester in charge and local force.

65. Utilization. To make ground wood pulp from hardwoods; birch, maple, beech, ash, and poplar.

1918: 60 cords of hardwood peeled by hand and ground. Very successful. 1919: 70 cords barked in tumbling barrels and made into ground wood pulp and then into paper; no difficulties. Knife barking also tried. Not successful.

Work will be continued and experiments made in floating, holding over for a season in water barking and transportation.

Assigned to Forester in charge and mill.

NEWFOUNDLAND

Commercial Organizations, Canada

Anglo-Newfoundland Development Company, Limited, Grand Falls, Newfoundland

Logging Department, J. D. GILMOUR, General Logging Supt.

66. Forest survey.

Started before the war, and has been recommenced. (For statement of Company's policy and local conditions see "Forestry Progress in Newfoundland; How Lord Northcliffe's Company Aims to Maintain Its Forests as a Permanent Crop," by J. D. Gilmour, in Canadian Forestry Journal, Vol. 15, No. 6, June, 1919.)

Will eventually give a complete topographic and forest survey of the entire limits, nearly 2,500,000 acres, which, in accordance with the Company's policy, will be handled for permanency.

Assigned to J. D. Gilmour.

67. Measurement.

Volume tables for computing strip surveys have been made locally. Growth tables, showing increment in volume, diameter breasthigh, and height, for different species and types have been made, although in some cases they require strengthening by further data. These so far are based on complete stem analyses.

Assigned to J. D. Gilmour.

68. Regeneration.

Regeneration studies to determine what new growth has followed clear cuttings, partial cuttings, and old burns have been made.

Assigned to J. D. Gilmour.

69. Management. To determine commercial feasibility in the pulp business of any logging system which will give a better second crop.

In 1918 five sample plots (acres) for logging to various diameter limits were laid off for annual observation.

Annual observation of plots established. Establishment of new plots proposed. Plots expected to yield valuable data in four or five years with reference to windfall among trees left behind, and in a longer period, with regard to increased rate of growth, if any, among the same trees.

Assigned to J. D. Gilmour.

70. Slash burning.

Last spring a small amount of slash burning was tried, both as a protection against fire and because light fires in the past—as indicated by reproduction tallies on over 100 sample plots—have been followed by a much more satisfactory crop than have areas left covered with slash.

To be tried on a more extensive scale.

Assigned to J. D. Gilmour.

UNITED STATES

FEDERAL AGENCIES

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

WILLIAM B. GREELEY, Forester

Branch of Research, Earle H. Clapp, Assistant Forester, in charge.
  S. T. Dana, Assistant Chief of Branch.
  Office of Dendrology, George B. Sudworth, Dendrologist.
  Office of Forest Investigations—Raphael Zon, Chief.
    District 1 (Northern), Missoula, Mont.
      Priest River Experiment Station, Priest River, Idaho.
        J. A. Larsen, in charge.
    District 2 (Rocky Mountain), Denver, Colo.
      Fremont Experiment Station, Colorado Springs, Colo.
        C. G. Bates, in charge.
      Wagon Wheel Gap Experiment Station, Wagon Wheel Gap, Colo.
        J. H. Jarboe, of the Weather Bureau, in charge.
    District 3 (Southwestern), Albuquerque, N. Mex.
      Fort Valley Experiment Station, Flagstaff, Ariz.
        G. A. Pearson, in charge.
    District 6 (North Pacific), Portland, Ore.
      Wind River Experiment Station, Stabler, Wash.
        J. V. Hofmann, in charge.
    Districts 7 and 8 (Eastern), Washington, D. C.
      Chief, Office of Forest Investigations, in charge.
    (Other investigators are also assigned to the above Districts and to District 4 (Ogden, Utah) and 5 (San Francisco, Calif.) for general and special investigations.)
  Forest Products Laboratory, Madison, Wis., C. P. Winslow, Director.
      O. M. Butler, Assistant Director.
    Derived Products—L. F. Hawley, in charge.
    Pulp and Paper—Otto Kress, in charge.
    Timber Mechanics—J. A. Newlin, in charge.
    Timber Physics—Rolf Thelen, in charge.
    Wood Preservation—George M. Hunt, in charge.
    Pathology—Paul V. Siggers, in charge.
  Office of Forest Products, Washington, D. C.; H. S. Betts, Engineer in Forest Products, in charge.
Branch of Grazing—Will C. Barnes, Assistant Forester, in charge.
  Grazing Studies—Wm. R. Chapline, Inspector of Grazing, in charge.
    District 3.
      Jornada Range Reserve, Las Cruces, N. Mex.
        E. W. Nelson, in charge.

Santa Rita Range Reserve, Tucson, Ariz.
R. R. Hill, in charge
District 4.
Great Basin Experiment Station, Ephraim, Utah.
A. W. Sampson, in charge.
(Other investigators also assigned to the above and the other Districts for general and special investigations in grazing.)

In classifying Forest Service investigative projects the following method of designation is used: The general and the special subjects are indicated by their initials, the former a capital letter. The number assigned to the project follows, or, in case an individual species is the subject of the study, its number in the Forest Service classification is usually given. In case the project relates to a still more specific point, this is indicated by a key letter in parenthesis; where this is done the key is included at the head of the list. In many cases the District to which the project is assigned is indicated by initial and number. Examples: Fs-101 (d) is Forestation, seed studies, western yellow pine, effect of source of seed upon the resulting stock. Mb-3, D-2, is Management, brush disposal, project No. 3, District 2.

FOREST INVESTIGATIONS

DENDROLOGY

71. Forest trees of the United States. To bring together in a comprehensive manner all the available information on the common names, geographical distribution, botanical characteristics, occurrence, and habits of forest trees by groups or genera.

Work begun in 1886. "Forest Trees of the Pacific Slope," "Cypresses and Junipers of the Rocky Mountain Region," "The Spruce and Fir Trees of the Rocky Mountain Region," "The Pine Trees of the Rocky Mountain Region," and "Miscellaneous Conifers of the Rocky Mountain Region" are completed and published. The manuscript of "The Walnuts, Willows, Poplars, Birches, Alders, and Oaks of the Rocky Mountain Region" is nearly completed.

Material is now partly completed for the following bulletins: "Part VII, Hackberry, Mulberry, Sycamore, Service-berry, Hawthorne, Plums, and Cherries, and Leguminous Trees of the Rocky Mountain Region." "Part VIII, Maples, Ashes, and Miscellaneous Smaller Groups, Completing Broadleaf Species of the Rocky Mountain Region."

George B. Sudworth, in charge.

72. Forest distribution studies (project B-1, D-8). To secure information concerning the botanical and commercial range of North American trees, including the preparation of range maps.

Work begun in 1913. Routine work consists in compilation of range notes, preparation of maps for publication showing geographical ranges of tree species, and identification of species from specimens sent in. During the war information was supplied on the distribution of species of war value, and special maps were prepared. Contributions to trade journals on the nomenclature, distribution, and economic value of many species were made, including the pines of Central and South America, the walnuts, and the woods called cedar. A chart showing the distribution of all coniferous trees growing west of the 99th meridian has been completed.

To be continued in accordance with previous plans, with emphasis upon educational aspects, as follows: (1) Popular identification of trees. Publications along the lines of the "Key to Common Kinds of Trees" (appendix to Farmer's Bull. 468). (2) An index of common names of the important timber trees of the world. A series of papers on nomenclature and distribution, now under way, will furnish the basis for such an index. (3) Preparation of articles dealing with the geographical distribution of North American trees, for publication in suitable journals. The charting of geographical distribution already completed for conifers growing west of the 99th meridian will be extended to include all important native trees.

Assigned to W. H. Lamb and Miss G. E. Wharton.

73. **Shrubs of the United States—Ceanothus (project B-2, D-8).** To secure information concerning the distinguishing characteristics and geographical distribution of the genus Ceanothus.

Work begun in 1913. Data collected consist of photographs of important types of Ceanothi, original type descriptions, data on economic value, and extensive information on the geographical distribution of the species, including a set of file maps showing the native range of each species. Enough material is on hand to warrant publication of popular and economic papers on the important and well-known species and of more technical papers on the little-known species and varieties.

To be completed with the preparation of reports from the material now on hand. Identification of species of Ceanothus for the Office of Grazing Studies, and others, will be continued under Project B-1, and additional data will be collected along certain lines.

Assigned to W. H. Lamb.

74. **Forest resources of Mexico, Central and South America (project B-3, D-8).** To bring together the available information on the timber resources of Mexico, Central and South America, as well as on other exotic woods, for use in correspondence.

Work begun in 1913. Additional notes have been secured on the forest resources of Cuba, Jamaica, Venezuela, Chili, and Colombia, and check lists of the trees of Brazil, Argentina, and Ecquador partly completed. A map of the forested area of Cuba has been prepared and a classification of the timbered areas of Mexico into natural forest regions begun.

The collection and compilation of data will be continued. As rapidly as possible this information will be presented in the form of popular articles for publication in lumber or other journals.

Assigned to Miss G. E. Wharton.

FORESTATION

General

75. **Relation of soil acidity to forest planting (project F-1, D-4).** To determine the causes of success or failure in forest planting on acid and alkaline soils.

Begun in 1909–10 on the Wallowa Forest, from a grazing standpoint. Previous to 1915 a number of soils were tested for acidity and alkalinity. During 1915 samples from a number of local soils were collected for testing. Seeds of western yellow pine, lodgepole pine, and Douglas fir have been sown in eight soils of different degrees of acidity and with correspondingly different physical properties. Great Basin Experiment Station.

Indefinite, pending revision of original plans.

Assigned to A. W. Sampson.

Seed Studies, General

76. **Seed storage experiments (project Fs-1, D-8).** Seeds of six conifers stored in 13 localities; in five different containers; and under three different temperature conditions.

Main part of experiment completed in 1914. A few additional tests of seeds stored for 10 years were conducted during the winter of 1918–19.

Experiment completed; final report under preparation.

Assigned to C. R. Tillotson.

77. **Physical characteristics and vitality of forest tree seeds (project Fs-2, D-8).**

A large number of tests of coniferous seeds completed.

To be continued: will be extended to include study of hardwood seed.

Assigned to C. R. Tillotson.

78. **To determine best methods of seed extraction**................ *a*

79. **Comparative germination in greenhouse and field**............. *b*

80. **Seed production**... *c*

81. **Effect of source of seed upon the resulting stock**.............. *d*

82. **Physiological characteristics of seed and methods of stimulating germination**.. *e*

83. **Methods of storing seed**.................................. *f*

Work in this subject was started in 1910, and is assigned to investigative and planting staffs in the District concerned. Twenty-nine studies are now under way in five Districts, as follows:

District 1.

Western yellow pine Fs-101 (*b*). Progress report, Priest River, 1918. Continuing at Savanac Nursery.

Western yellow pine Fs-101 (*d*). Progress report, 1918. Continuing at Savanac Nursery and Priest River.

Western white pine Fs-102 (*b*). Progress report, Priest River, 1918. Continuing at Savanac Nursery.

Western white pine Fs-102 (*d*). Priest River; no work done. Working plan to be made.

Western larch Fs-141 (*b*). Progress report, Priest River, 1918. Continuing at Savanac and Priest River.

Douglas fir Fs-161 (*b*). Progress report, Priest River, 1918. Continuing at Savanac and Priest River.

Western red cedar Fs-182 (*b*). Continuing at Savanac and Priest River.

District 2.

Western yellow pine Fs-101 (*a*, *b*, *c*, *d*). (*a*) and (*b*) final reports under preparation; (*c*) continuing at Cochetopa, Colorado, and Harney National Forests; (*d*) continuing at Nebraska National Forest.

Lodgepole pine Fs-103 (*a*, *c*, *d*). (*a*) final reports under preparation; (*c*) continued at Gunnison and Medicine Bow National Forests; continued at Fremont National Forest.

Engelmann spruce Fs-146 (*b*, *c*, *d*). (*b*) final reports under preparation; (*c*) continuing at Uncompahgre and White River National Forests; (*d*) continuing at Fremont National Forest.

Seed Studies, Species

Douglas fir Fs-161 (*b*, *c*, *d*). (*b*) final reports under preparation; (*c*) continuing at Washakie and Pike National Forests; (*d*) continuing at Fremont National Forest.

District 3.

Western yellow pine Fs-101 (*d*). Fort Valley Experiment Station. Experiments carried on since 1908. A large number of plants have been field planted. Conclusive data on effect of geographical source of seed secured, but data on effect of age and character of tree not conclusive. Publication: "The Influence of Age and Condition of the Tree upon Seed Production in Western Yellow Pine," by G. A. Pearson. Forest Service Circular 196, 1912.

Continuing. Several lots of stock to be field planted in 1919. All old plantations to be thoroughly examined; report now in preparation, to be completed in 1919.

District 5.

Western yellow pine Fs-101 (*d*).

Sugar pine Fs-104 (*d*).

Jeffrey pine Fs-108 (*d*).

Douglas fir Fs-161 (*d*).

Incense cedar Fs-181 (*d*). Installed in 1917–18, Feather River. Reports on behavior of seed and initial survival to be made next winter. Plots to be observed for an indefinite period for differences in growth.

District 6.

Douglas fir Fs-161 (*d*). Wind River Nursery; progress report 1918. Publications: "Incidental Results of a Study of Douglas Fir Seed in the Pacific Northwest," by C. P. Willis, Jour. Forestry, Dec. 1917, Vol. 15, No. 8, 991–1002; "A Study of Douglas Fir Seed," by C. P. Willis and J. V. Hofmann, Proc. Soc. Am. Foresters, April, 1915, Vol. 10, No. 3, 141–64; "Choosing the Best Tree Seeds: The Influence of Parental Character and Environment upon the Progeny of Douglas Fir," by C. J. Kraebel, Jour. of Heredity, Nov. 1917, Vol. 8, No. 11, 483–92.

Noble fir Fs-166 (*f*). Begun in winter of 1917–18, when seed stored under six different conditions. In the spring germination tests were made and counts throughout the summer. Wind River Experiment Station. Continuing. The tests will remain in storage for five years.

Amabilis fir Fs-169 (*f*).

Nursery practice	*Project*
84. Best amount of seed to sow	*a*
85. Time of sowing	*b*
86. Preliminary treatment of seed	*c*

87.	**Depth of covering seed**	*d*
88.	**Methods of sowing**	*e*
89.	**Fertilizing**	*f*
90.	**Shading**	*g*
91.	**Watering**	*h*
92.	**Root development**	*i*
93.	**Time and method of transplanting**	*j*
94.	**Methods of retarding spring growth in nursery stock**	*k*
95.	**Best method of packing stock for shipment**	*l*
96.	**Value of various mulches in seed and transplant beds**	*m*
97.	**Protection of nursery stock from frost and winter injury**	*n*

Work in this subject was started in 1910, and is variously assigned in different Districts to members of the planting and investigative staffs: 57 studies are now under way:

District 1.

Western yellow pine Fn-101 (*a, b, c, f, g, i*). Continuing at Savanac; (*a*) and (*b*) to be completed 1920.

Western white pine Fn-102 (*b, c, d, g, i*). (*b*) Completed at Priest River. Continuing at Savanac; (*g*) to be completed in 1920.

Engelmann spruce Fn-146 (*a, b*). Continuing at Savanac.

Western red cedar Fn-182 (*b, d*). Continuing at Savanac.

District 2.

Western yellow pine Fn-101 (*g, i*). Nebraska National Forest. Probably conclusive results 1919.

Norway pine Fn-105 (*b, j*). Minnesota National Forest. Final report about 1923.

Jack pine Fn-106 (*g, i*). Nebraska National Forest. Final report in 1919, probably.

Eastern white pine Fn-107 (*b, j*). Minnesota National Forest. Final report about 1923.

District 3.

Western yellow pine Fn-101 (*a*). Work at Ft. Bayard Nursery completed. Final report Ft. Valley Experiment Station and Gallinas Nursery under preparation.

Western yellow pine Fn-101 (*j*). Work at Ft. Bayard Nursery completed. Final report Ft. Valley Experiment Station and Gallinas Nursery under preparation.

Engelmann spruce Fn-146 (*a, j*). Gallinas Nursery. Continuing.

Douglas fir Fn-161 (*a, j*). Gallinas Nursery. Continuing.

District 4.

Lodgepole pine Fn-103 (*g*). Great Basin Experiment Station. Continuing.

Engelmann spruce Fn-146 (*g*). Great Basin Experiment Station begun in 1918. Continuing.

Douglas fir Fn-161 (*a, c, d, g, n*), (*a, d, g, n*). Cottonwood Nursery begun in 1918. Continuing, except (*c*), final report in preparation.

District 5.

Western yellow pine Fn-101 (*b, g, h*)
Sugar pine Fn-104 (*c*)
Jeffrey pine Fn-108 (*b, g, h*)
Incense cedar Fn-181 (*b, g, h*)

Converse Nursery; field work completed; final reports under preparation.

Red fir Fn-168 (*d*). Discontinued; final report under preparation.

Austrian pine Fn-501 (*b*). Completed; final report under preparation.

Deodar cedar Fn-504 (*g*). Completed; final report under preparation.

District 6.

Western white pine Fn-102 (*c*)
Douglas fir Fn-161 (*c, f*)
Noble fir Fn-166 (*a, b, c*)
Amabilis fir Fn-169 (*a, b*)

Wind River Experiment Station. (*a*) Different densities of fall and spring-sown 2–0 stock; survival counts taken of bud condition and size of tops and roots when transplanted and again in the fall. Stock to be field planted in spring and examined in fall for survival, growth, and bud maturity. (*b*) Records of germination, daily soil temperature, bud maturity, size of tops and roots, damping off, and cultures of diseases causing loss. (*c*) Second annual examination of plantations; data on current and total growth and bud maturity. Annual examination in fall to determine growth and bud maturity. (*f*) Nine different fertilizers; data on germination, bud maturity, size of tops and roots, losses through damping-off, and cultures of diseases causing loss. Continued observations during second year in seed beds. Record to be made in the fall of bud maturity, size of roots and tops, and density of stand.

Sowing and planting, general

98. Value of native plants as indicators of planting sites (project Fp-6, D-4). To ascertain the value of native vegetation as indicative of soil and climatic conditions under which certain important conifers may be successfully planted.

Begun in 1916. Work carried on at the Great Basin Experiment Station. Studies made of the root system and successions in the oak brush zone, and a preliminary study of the western yellow pine type on the Manti National Forest, in which a meteorological station was established. Later supplemented by soil analyses. See Korstian, C. F., "The Indicator Significance of Native Vegetation in the Determination of Forest Sites." Plant World, Vol. 20, No. 9, pp. 267–287, September, 1917.

Advisability of further work along the lines suggested by the District is doubtful.

Assigned to C. F. Korstian.

99. Preparation of two farmers' bulletins on planting (project Fp-18, D-8).

Bulletin entitled "The Growing of Hardwood Trees in the Home Nursery and Planting them on the Farm" completed for publication.

Bulletin on the planting of coniferous trees in course of preparation. Additional species to be transplanted from the nursery. Further planting to be done as new material becomes available.

Assigned to C. R. Tillotson.

100. Arboretum, establishment and maintenance (project Fp-2, D-6, 8). D-8 project formerly designated as Z-3, D-8, Special Studies.

District 7.

At Wind River Experiment Station. In 1918 trees relabeled and numbered, and data on growth and condition recorded. Assigned to investigative staff.

District 8.

At Rock Creek Park, Washington, D. C. Begun 1912. About 669 conifers and 960 hardwoods, of about 225 species and varieties, now growing. Practically all the broadleafed trees except ginkgo were more or less seriously injured by the 17-year locust in June, 1919, and a number will probably die as a result.

Sowing and planting, species.

101. The most suitable species .... *a*
102. Classes of stock to use .... *b*
103. Advantages of grading seedlings .... (b^2, D-2)
104. Best season for sowing and planting .... *c*
105. Best methods of sowing and planting .... *d*
106. Effect of cover .... *e*
107. Sites most suitable to the different species .... *f*

Work in this subject was started in 1910, and is assigned to the planting and investigative staff except where noted; 104 studies are now under way:

District 1.

Western yellow pine	Fp-101 (*b, c, d, f*)	At Savanac Nursery; (*b*) also at Priest River Experiment Station.
Western white pine	Fp-102 (*b*)	Priest River and Wallace, Idaho; progress report 1919.
Western white pine	Fp-102 (*c*)	Work at Priest River completed 1918.
Western white pine	Fp-102 (*d*)	Haugan, Mont., and Wallace, Idaho; completed at Priest River 1918.
Western white pine	Fp-102 (*f*)	Haugan, Mont., and Wallace, Idaho; progress report 1917.
Western larch	Fp-141 (*b, c, d, f*)	Haugan, Mont., and Wallace, Idaho; completed at Priest River, 1917.
Engelmann spruce	Fp-146 (*d*)	
Sugar pine	Fp-104 (*a*)	Individual progress reports, submitted in 1918, will be combined into a general report. Some tests are being made at Wallace under the supervision of the Office of Planting. Most of the tests are at Priest River, and a number at the Savanac Nursery. A new comprehensive working plan to be prepared and new installations made on more suitable sites. Conclusive data not forthcoming until 1930.
Norway pine	Fp-105 (*a*)	
Eastern white pine	Fp-107 (*a*)	
Colo. blue spruce	Fp-149 (*a*)	
Bigtree	Fp-177 (*a*)	
Hardwoods	Fp-300 (*a*)	
Scotch pine	Fp-500 (*a*)	
Austrian pine	Fp-501 (*a*)	
Norway spruce	Fp-505 (*a*)	
European larch	Fp-506 (*a*)	
Japanese larch	Fp-507 (*a*)	
Siberian larch	Fp-508 (*a*)	

District 2.

Western yellow pine	Fp-101 (*a*, b^1, b^2, *c*)	(*a*, b^1, b^2) Nebraska, (*c*) Fremont National Forests; final reports under preparation.
Western yellow pine	Fp-101 (*f*)	Nebraska National Forest.
Western white pine	Fp-102 (*a*)	Fremont National Forest; final report expected in 1919.
Lodgepole pine	Fp-103 (*a*, *c*)	(*a*) Fremont, (*c*) Colorado and Routt National Forests; (*a*) continuing, (*c*) final report under preparation.
Norway pine	Fp-105 (*a*, *b*)	(*a*) Fremont, medicine Bow and Nebraska National Forests; (*b*) Michigan National Forest; (*a*) final report due 1919; (*b*) continuing.
Jack pine	Fp-106 (b^2)	Nebraska National Forest; final report under preparation.
Engelmann spruce	Fp-146 (*c*)	Fremont and Cochetopa National Forests; final report under preparation.
Douglas fir	Fp-161 (*a*, *c*)	(*a*) Arapaho and Medicine Bow; (*c*) Fremont, Bighorn, Durango and Sopris National Forests; (*a*) continuing; (*c*) final report under preparation.
Scotch pine	Fp-500 (*a*, *b*)	(*a*) Fremont, Nebraska, (*b*) Nebraska National Forests; (*a*) continuing; (*b*) final report under preparation.
Austrian pine	Fp-501 (*a*)	Fremont, Nebraska and Uncompahgre National Forests; final report expected in 1919.
Corsican pine	Fp-502 (*a*)	Nebraska National Forest; final report expected in 1919.
Norway spruce	Fp-505 (*a*)	Fremont National Forest; final report expected in 1919.
Japanese larch	Fp-507 (*a*)	Fremont National Forest; continuing
Siberian larch	Fp-508 (*a*)	Fremont National Forest; to be completed in 1920.

District 3.

Western yellow pine	Fp-101 (*f*)	Ft. Valley Experiment Station, Ft. Bayard and Gallinas Nurseries Continuing.
Engelmann spruce	Fp-146 (*c*, *f*)	(*c*) Gallinas Nursery, (*f*) Ft. Valley Expt. Station, and Gallinas Nursery; continuing.
Douglas fir	Fp-161 (*c*, *f*)	Gallinas Nursery; continuing.
Norway spruce	Fp-505 (*a*)	Fort Valley Experiment Station; continuing.

District 4.

Western yellow pine	Fp-101 (*b*)	Great Basin Experiment Station, Cottonwood Nurseries.
Western yellow pine	Fp-101 (*c*)	Great Basin Experiment Station.

Western yellow pine	Fp-101 (*f*)	Great Basin Experiment Station; Fishlake and Targhee National Forests, Cottonwood Nursery.
Western white pine	Fp-102 (*a*)	Continuing.
Lodgepole pine	Fp-103 (*b, f*)	(*b*) Targhee National Forest; (*f*) Great Basin Experiment Station and Targhee National Forest.
Engelmann spruce	Fp-146 (*b, f*)	(*b*) Great Basin Experiment Station; (*f*) Great Basin Experiment Station and Cottonwood Nursery.
Blue spruce	Fp-149 (*f*)	Great Basin Experiment Station.
Douglas fir	Fp-161 (*b*)	Great Basin Experiment Station; and Targhee National Forest.
Douglas fir	Fp-161 (*f*)	Great Basin Experiment Station; Targhee Cache and Wasatch National Forests.
Norway spruce	Fp-505 (*f*)	Great Basin Experiment Station.

District 5.

Western yellow pine	Fp-101 (*a, b, c, f*)	Converse Nursery.
Western yellow pine	Fp-101 (*c, f*)	Feather River Experiment Station.
Sugar pine	Fp-104 (*c, f*)	Feather River Experiment Station.
Jeffrey pine	Fp-108 (*c, f*)	Feather River Experiment Station.
Jeffrey pine	Fp-108 (*a, b, c, e, f*)	Converse Nursery.
Douglas fir	Fp-161 (*c, f*)	Feather River Experiment Station.
White fir	Fp-167 (*c, f*)	Feather River Experiment Station.
Incense cedar	Fp-181 (*c, f*)	Feather River Experiment Station.
Incense cedar	Fp-181 (*c, f*)	Converse Nursery.

All planting experiments at Converse Nursery and the (*c*) experiments at Feather River to be completed by submission of a final report this winter. At Feather River the (*f*) experiments are in a broad sense continuous, though a report will be submitted this winter.

District 6.

Western yellow pine	Fp-101 (*c,d*)	Wind River Experiment Station.
Noble fir	Fp-166 (*c, d, f*)	Final reports on (*c*), (*d*), and (*f*) under preparation. (*a*), continuous.
Siberian larch	Fp-108 (*a*)	Assigned to investigative staff.

District 7.

Maritime pine	Fp-503 (*a*)	Florida National Forest. Assigned to investigative staff D-8.
Eucalyptus	Fp-700 (*a*)	
Cork oak	Fp-701 (*a*)	

District 8.

Loblolly pine Fp-111 (*a*). Begun in 1908, when 7 seed beds and 5 half-acre plots were started, the latter by direct seeding; few seeds germinated, and seedlings later killed by drought. From 1910 to 1913 8 plots aggregating about 8.4 acres were planted with seedlings or transplants under different conditions; about 3 acres showed success when examined in 1919. Results indicate success of seedlings (when once established) on the sands of south Jersey, but failure on heavier clay soils of north Jersey due to injury to terminals from early or late cold winds.

Assigned to W. R. Mattoon, in cooperation with New Jersey State Forester.

Completed.

Maritime pine Fp-503 (*a*). Begun in 1912. From 1912 to 1914 12 plots aggregating about 5 acres were started, mostly by direct seeding. Results when examined in 1919 show almost total failure. Seedlings died off rapidly due apparently to winter killing. Surviving two per cent of seedlings planted (2–0) appear healthy. Maritime pine apparently not adapted to the sandy soils of south Jersey, being injured by winter-killing and perhaps by drought and hot sun. Assigned to W. R. Mattoon, in cooperation with New Jersey State Forester. Completed.

Loblolly pine Fp-111 (*a*, *c*)
Longleaf pine Fp-112 (*a*) } Summerville, S. C.
Shortleaf pine Fp-113 (*a*)

Plot burned over February, 1917. Previous plantation destroyed. Seed-spot and broadcast sowing planned for March, 1918, not carried out on account of the war. Definite plans for continuing this project have not been made. Assigned to W. R. Mattoon, in cooperation with Clemson College Expt. Station.

Slash pine Fp-118 (*a*). Summerville, S. C.

Plots established 1918 (spring). No plans pending examination. Assigned to W. R. Mattoon, in cooperation with Clemson College Expt. Station.

Willows Fp-301. Development of American willows, Arlington, Va. Future plans indefinite.

Assigned to Office of Forest Investigations.

INFLUENCES.

108. Effect of forest and brush cover on streamflow. Douglas fir and spruce type (project I-1, D-2).

Begun in 1910 at the Wagon Wheel Gap Experiment Station. Records for eight full years completed October 31, 1918. Denudation of Watershed B in progress, summer of 1919.

After denudation is completed observations will be continued on the two watersheds for several more years. Meanwhile the weather and stream data are being analyzed by both the Weather Bureau and the Forest Service, and the material published in the Monthly Weather Review.

Assigned to C. G. Bates in cooperation with the Weather Bureau.

109. Effect of willow planting on erosion (project I-2, D-2). To test the possibility of checking erosion in eroding mountain gullies in the Pike's Peak region by planting willow cuttings.

Plantings of willow cuttings along a single gully were made in 1910, 1911, 1912, and 1916. Although the percentage of survival has each year been low, the loose soil spots in the gully are gradually being filled. The main record in the past few years has been a series of photographs taken annually to show the change which takes place. The photos taken in 1915 and 1916 were failures.

Continuing. The photographic record is to be kept up for a number of years, until conditions become stable.

Assigned to Fremont Experiment Station.

110. **Influence on streamflow of (1) chaparral cover, (2) fires in the chaparral, and (3) check dams (project I-1, D-5).**

Begun in 1916 on the Angeles Forest. Progress reports on "Effect of Chaparral on Streamflow, Waterman and Devil Canyons," and "Effect of Check Dams on Storm Waters," submitted in 1916. Descriptive reports on eight other canyons submitted in 1918–19. A method of rating the protective value of chaparral so as largely to eliminate the variable factor of individual judgment was devised. Mapping of the forest cover of the important watersheds completed.

A more intensive study of small selected watersheds similar to the Wagon Wheel Gap project is needed to place the conclusions on a firm basis. Its initiation will depend, however, upon available funds and future experimental work in California.

Assigned to E. N. Munns, in cooperation with Office of Engineering (Forest Service) and the Geological Survey.

111. **Dissipating effect of chaparral and forest cover on precipitation (project I-2, D-5).** To determine the relative value of chaparral and forest cover as a conserver of water as indicated by the quantity of precipitation reaching the ground on adjoining areas of forest and chaparral, the rate of evaporation, etc.

Work begun in 1913 and continued until the abandonment of the Converse Experiment Station on June 30, 1917. Daily records taken of temperature, precipitation, humidity, and soil moisture, and data worked up in monthly decades.

Final report under preparation.

Assigned to E. N. Munns.

112. **Influence of forests upon melting of winter snow (project I-1, D-6).**

Begun 1916, Columbia and Deschutes Forests, on representative drainage basins. Semi-weekly observations and measurements of the melting of snow made at several sites in each locality representative of various exposures in forested and non-forested spots. Publication: "Influence of Forests Upon the Melting of Snow in the Cascade Range," by A. A. Griffin, U. S. Weather Bureau, Monthly Weather Review, July, 1918, Vol. 46, No. 7, 324–7.

Completed.

Assigned to A. A. Griffin and W. J. Sproat.

MANAGEMENT

General

113. **Study of plantations on the Biltmore Estate, with special reference to their past history, present condition, and future management (project M-1, D-7).** To determine the results that may be secured from artificial reforestation with various species in the Southern Appalachians.

Begun in 1915. During 1916 thinnings were made on four plantations on the Biltmore Estate and sample plots were established. These plots to be remeasured every five years.

If possible, additional thinnings will be made on other plantations on the Biltmore Estate and sample plots established.

Assigned to V. Rhoades and Office of Forest Investigations, D-8.

114. **Woodlot management studies (project M-5, D-8).** To bring together all available information on the management of woodlots in the

United States as a basis for improved methods of marketing woodlot products and better care of the woodlot. (See also under Forest Economics, Project E-10, D-8.)

Work begun in 1913, in cooperation with various States. Cooperative reports published for the States of Maine, Wisconsin, Michigan, Indiana, Kentucky, Tennessee, Missouri, South Carolina, and Georgia. Publications pending for the States of North Carolina and West Virginia. Three general woodlot bulletins have been published by the U. S. Department of Agriculture.

No additional work contemplated for the ensuing year.

Assigned to Office of Forest Investigations.

Brush disposal

115. Methods of brush disposal (projects Mb-1, D-1, 3, 4). To determine the most effective and cheapest method of brush disposal, taking into consideration reproduction, fire risk, and effect of grazing.

District 1.

(*a*) Lodgepole pine. Deerlodge Forest. Work on new project yet to be started. Publication: "Brush Disposal in Lodgepole Pine Cuttings," by D. T. Mason, Proc. Soc. Amer. Foresters, Oct. 1915, Vol. 10, No. 4, 399–404.

Continuing.

Assigned to investigative staff.

District 3.

(*b*) Western yellow pine. Coconino Forest. Begun in 1908, when brush was scattered on an area of 126 acres under fence. Examinations made every 1 or 2 years show both beneficial and detrimental effects. Practice has recently been greatly influenced by Dr. Long's results in studies of progress of decay (projects Mb-2 and Mb-3). Plans for this project (Mb-1) extended in 1916–17 to cover all phases of brush disposal and correlate all available data, particularly timber sale and fire reports, toward formulating a sound brush disposal policy. Work along new lines interrupted in 1917, after a 3 months' study by W. L. Scofield. Publications: "Brush Disposal—Fort Valley Experiment Station," by G. A. Pearson, Rev. Forest Service Investigations, 1913, Vol. 2, 78–81.

Continuing. To be extended from the Coconino and Tusayan to other Forests. The compilation of data from all available sources to be completed this year, if a man becomes available for the work.

Assigned to investigative staff.

District 4.

(*c*) Sheep grazing to reduce fire damage in lodgepole pine slash. Wasatch Forest. Begun in 1915, when 5 acres were fenced and the brush on one part piled and burned, on the other part scattered. Check area established outside of the fence in 1916.

Continuing.

Assigned to investigative staff.

116. Investigations on the rotting of slash in relation to the different methods of brush disposal (projects Mb-2, D-1; Mb-2, D-3, formerly designated Pd-6, D-3; Mb-3, D-3, formerly designated Pd-7, D-3, To determine the factors governing the rotting of brush and logs.

District 1.

(*a*) New project (Project Mb-2, D-1).

Extensive study planned for this year. Date of completion indefinite.

Assigned to Dr. J. R. Weir, Forest Pathologist.

District 3.

(*b*) Rate of decay of logs on burns on municipal watersheds in relation to the run-off (Project Mb-2, D-3). Begun as a project in 1916, although some work had been done before. Preliminary study indicates that 30–40 years' decay of logs will terminate retarding influence on run-off. *Lenzites sapiaria* practically the only fungus found causing the rotting of lots on these burns.

Continuing for at least one more year.

Assigned to Dr. W. H. Long, Forest Pathologist.

(*c*) Rate of decay, causes of difference in rate, effect upon reproduction, and other features, when slash is (1) piled, (2) scattered, and (3) pulled. (Project Mb-3, D-3). Begun as a project in 1916, although some work had been done before. In brush piled in the western yellow pine type progress of decay is from top of pile downwards, as sun's rays are admitted; decay usually more rapid when unlopped than when lopped and scattered. In Arkansas decay in piles is from both top and bottom. Two groups of fungi thus demonstrated: (1) ground fungi, requiring moisture; (2) fungi which apparently need little moisture including most fungi in District 3 which rot slash.

Continuing for at least one more year.

Assigned to Dr. W. H. Long, Forest Pathologist.

Methods of cutting

117. Effects of different methods of cutting. To determine the best methods of cutting in different forest types to secure natural reproduction in the shortest possible time. There are now 14 experiments under way in seven Districts

District 1.

(*a*) Western white pine, western larch, western yellow pine, Douglas fir, and lodgepole pine on the Kaniksu, Coeur d'Alene, Pend Oreille, Clearwater, and Deerlodge (Mc-1, D-1). Studies begun on 30 areas in the western white pine type in 1912–13, yielding evidence in support of the theory that white pine seed is capable of lying over in the duff for several years and of then germinating upon introduction of greater heat and light admitted after cutting operations. This evidence led to a radical change in marking rules and methods of brush disposal in white pine type. In 1914 a one-acre plot was established on the Coeur d'Alene Forest, and about 20 pounds of fresh white pine seed was placed in several series of wire baskets at different depths in the duff and under different degrees of shading, one basket under each depth and degree of shading to be taken up each year for 15 years and germinated, another to be subjected to a burning test. In 1915 intensive studies were made of the revised marking rules and two permanent plots of 4 acres each were laid out. Further revision of marking rules was prepared as a result of these studies. In 1916 special studies of girdling were conducted, sample plots reexamined, and a progress report prepared. Additional plots were laid out and existing plots reexamined in 1917–18. Emphasis was placed on methods of cutting in white pine and on determination of the extent and conditions under which reproduction can be depended upon from seed stored in the duff.

To be continued in accordance with the working plan.

Assigned to investigative staff.

District 2.

(*b*) Lodgepole pine, Medicine Bow Project (Mc-1, D-2). Begun in 1909, when eight plots representing selection, group selection, and clear-cutting methods were established. First complete reproduction count in 1913 showed greatest number of seedlings in group selection, next best under selection, next under unbroken canopy, and fewest, but much the most thrifty, in clear cutting (about 4,000 per acre). Under all methods burning brush proves more favorable to germination than scattering. Second count, in 1915, substantiated these conclusions. Progress report on "Lodgepole Cutting System with a View to Reproduction," by Frank B. Notestein, submitted November 5, 1915.

Semi-final report expected in 1921.

Assigned to C. G. Bates and local forest force.

(*c*) Lodgepole pine, Gunnison (Mc-2, D-2). Begun in 1911 on 60 acres cut experimentally in seven strips representing (1) very heavy and (2) moderate thinning; (3) clear cut 200 and (4) 300 feet wide; (5) uncut 150, (6) 200, and (7) 400 feet wide. In 1913 two continuous strips of 10′ x 10′ sample plots transecting the major strips were laid out and counts made, which show practically no reproduction on the uncut strips, but from 600 to 5400 seedlings per acre on the cut-over strips, the number being in all but one case directly proportionate to present light intensity. Second count, in 1916, shows that good trees are becoming established only in clear-cut areas and those thinned most heavily. Progress reports by H. S. Borden, 1913 and 1916.

Continuing. Third reproduction count to be made in 1919.

Assigned to C. G. Bates and local forest force.

(*d*) Engelmann spruce—Fremont, Holy Cross, Rio Grande (Project Mc-3, D-2). Working plans were prepared in 1911 and 1913. Plots were laid out on the Rio Grande in 1913–14, and on the Holy Cross in 1914. Lack of timber sale opportunities has prevented more than preliminary work up to the present.

Continuing.

Assigned to C. G. Bates and local forest force.

(*e*) Douglas fir—Fremont, Pike (Project Mc-4, D-2). Attempts at beginning this project were made in 1910, 1911 and 1912, but nothing accomplished until 1913 when work was begun under a new working plan; four 1-acre plots, cut by selection, shelterwood, and clear-cutting systems, with one intact control plot, were established; brush largely burned, and all existing reproduction less than $4^1/_2$ feet high destroyed. Partial count of reproduction made in 1915. Complete reproduction count made in 1916 showed a surprisingly large amount of new germination from the 1914 seed crop, the most seedlings being in the uncut check plot where the density is very great. The reproduction in the clear-cut area is largely of other species than Douglas fir, indicating that seeding is by animal agencies rather than by wind. A progress report was prepared in 1917.

Continuing. Reproduction counts to cover 20 per cent of the area of each plot to be made in the fall of each year. Growth measurements on the stands left after cutting will be made at intervals of about five years.

Assigned to C. G. Bates and local forest force.

(*f*) Spruce, Balsam—Leadville (Project Mc-5, D-2). Begun in 1911 and original survey completed 1912. Covers four 1-acre plots cut about 15, 30, 40, and 43 per cent respectively. All plots showed at outset nearly 50 per cent balsam in seedling and 30 per cent in sapling class. Reexamined in 1914 and 1915–16. No conclusive results as yet.

Progress report for 1919 under preparation.

Assigned to C. G. Bates and local forest force.

District 3.

(*g*) Western yellow pine and Douglas fir—Fort Valley (Project Mc-2, D-3). Begun in 1909. Nineteen permanent sample plots aggregating about 2000 acres have been established on the Coconino, Datil, Apache, Pecos, Jemez, and Gila Forests. About 90 per cent of the acreage is in the form of "extensive" and 10 per cent of "intensive" plots. Most of these plots have been remeasured once. Results up to 1918 are embodied in "Studies of Yield and Reproduction of Western Yellow Pine in Arizona and New Mexico," by G. A. Pearson, Jour. Forestry, Vol. 16, No. 3, March, 1918, pp. 273–293.

Continuing. The schedule is arranged so that several plots are due for remeasurement each year. In 1919 some 1200 acres, established 10 years, to be remeasured.

Assigned to G. A. Pearson and investigative staff.

District 4.

(*h*) Aspen—Great Basin (Project Mc-1, D-4). Begun in 1912–13, when two permanent plots established, to determine (1) relative vigor of sprouting on areas clear cut in autumn, spring, and midsummer, and (2) effect of cutting out the prop sizes (7″ — 10″ DBH) from all aged stands. In 1914 six additional plots were established, three for prop cuttings and three for clear cutting at different ages. In 1915 small plots were laid out to study the effect of thinning sprouts, and transects were established on three plots cut in 1914. In 1916 cuttings were made (1) in the spring, summer, and fall to determine best season for production of sprouts, and (2) in stands of different ages to determine age of maximum sprouting. Records on transects secured annually.

Plots to be remeasured in 1919 and the results combined with those of projects Mt-1, ME-2, and ME-3 as the basis for a report which will be submitted for publication.

Assigned to F. S. Baker.

(*i*) Western yellow pine—Payette (Project Mc-2, D-4). Begun in 1913, when three 5-acre plots were laid out, mapped, marked by the seed-tree method, and cut over. In each plot two reproduction plots of 500 sq. ft. each were established. In 1914–15, twelve 5-acre plots were laid out but not cut over. These comprise three plots, each to be cut by group selection, strip, and clear cutting with groups of seed trees; 13 reproduction plots were established, and a large number of light readings and soil moisture determinations made. A progress report was submitted by E. R. Hodson, in 1913.

Continuing.

Assigned to C. F. Korstian.

District 5.

(*j*) Study of cut-over areas on timber sale operations (Project Mc-1, D-5). Begun in 1910. Eight plots of 6.4 acres each were laid out on the Plumas Forest and all but two marked for cutting. Four plots cut over in 1913. Reproduction plots 50′ × 100′ were established and counts made previous to cutting on major plots. Permanent plots have been established on seven Forests. Progress reports were submitted in 1918 by S. B. Show, on plots on the Tahoe, Sierra, Plumas, and Sequoia Forests.

Continuing.

Assigned to S. B. Show.

(*k*) Practical aspects of the forest sanitation clause (Project Mc-2, D-5). Begun in 1911, but first extensive work done in 1913 on timber sales. Object (1) to secure a check of estimated cull of standing timber by actual sale; (2) to ascertain cost of handling diseased trees and snags under the Sanitation Clause and its bearing on the stumpage rate (3) to determine the actual saving in merchantable logs from trees cut under the Sanitation Clause. Method: On a representative area all trees, including snags, above diameter limit, are tagged and described by number. In lumbering, each log is identified with its tree, and the scale and deduction with reason for deduction, tallied. After completion of logging the area is surveyed and mapped.

Work to be continued on other sale areas as occasion arises.

Assigned to Dr. E. P. Meinecke, in cooperation with the investigative staff and local Forest officers.

District 6.

(*l*) Western yellow pine (Project Mc-101, D-6). Work begun in 1911 with establishment of a 40-acre plot on the Crater Forest, which was clear-cut and eliminated from the Forest as agricultural land in 1913. Two large plots were laid off on the Whitman in 1913 and marked for cutting; the cutting was done in 1914, the brush being burned, trees tagged and quadrats established. A field study of old yellow pine cut-over areas was made in 1914–15 by Field Assistant Weitknecht on and near the Whitman Forest, and continued in 1916 on the Minam, Ochoco, and Malheur Forests; a complete report on this work was submitted by Mr. Weitknecht in 1916 ("Study of Methods of Cutting Yellow Pine in Oregon." Revised and enlarged in 1917, under title "Yellow Pine Management Study in Oregon in 1916." Also "Preliminary Report of Yellow Pine Management Study of the Crater National Forest," 1917, and "Further Data on Distribution of Accelerated Increment in Western Yellow Pine," 1918. All manuscript reports by Mr. Weitknecht).

Continuing. Reports to be revised for publication.

Assigned to R. H. Weitknecht.

(*m*) Douglas fir (Project Mc-161, D-6). Begun in 1910 with establishment of a 75-acre plot on the Columbia Forest. Seed trees tagged, measured, and described, and the reproduction on 110 square rod sample plots counted. Remeasured in 1915, and results embodied in "Five Years' Growth of Douglas Fir Sample Plots," by T. T. Munger, Proc. Soc. Amer. Foresters, Vol. 10, No. 4, Oct., 1915, pp. 423–5.

Assigned to T. T. Munger.

Completed. Final report on six remeasurements now under preparation.

District 7.

(*n*) Study of cut-over areas, White Mountain National Forest (Project Mc-1, D-7). Working plan prepared in 1916. No definite results as yet.
Continuing.
Assigned to local Forest force.

Natural reproduction

118. Factors affecting natural reproduction. To determine means of encouraging reproduction and to find the rate of loss of seedlings during the early stages of development, and the factors responsible. Five experiments are now under way in five Districts:

District 1.

(*a*) Western white pine and associated species, Priest River Experiment Station and Coeur d'Alene Forest (Project Mr-1, D-1). Begun 1912. Final report, "A Study of the Factors Affecting Natural Reproduction," by J. A. Larsen, submitted 1918.
Assigned to J. A. Larsen.
Completed.

(*b*) Hastening regeneration of logged stands by sowing seed previous to cutting Priest River (Project Mr-2, D-1). New Project. Working plan prepared in 1919.
To be undertaken in connection with sales on the Experimental Forest and possibly the Kaniksu Forest. Can be completed in three years if suitable conditions are promptly available.
Assigned to J. A. Larsen.

District 2.

(*c*) Norway pine—Michigan National Forest (Project Mr-2, D-2). Begun in 1917 by Supervisor Hilton on plans prepared by Forest Examiner Bates. An area of about five acres was surrounded by a fire line and 98 plots, each 40 feet square, representing different conditions, laid out and mapped, showing location of all seed trees in and close to the plots. Fifteen selected sections mapped and described as to location and character of seed trees, Norway saplings and seedlings, and amounts of jack pine hardwoods and ground cover cones and soil samples secured for testing. Progress reports submitted in 1917 and 1918 by Mr. Hilton.
Continuing.
Assigned to C. G. Bates and H. C. Hilton.

District 3.

(*d*) Western yellow pine—Ft. Valley Experiment Station, Coconino and Apache National Forests (Project Mr-1, D-3). Begun on the Coconino in 1908, with establishment of five plots aggregating 12,475 sq. ft., and on the Apache in 1910 where two plots comprising 13,500 sq. ft. were laid out. Counts made on Coconino plots annually from 1908 to 1913, in 1915, and subsequently in connection with project Mc-2; on the Apache plots in 1910, 1911, 1914, and subsequently. Results up to 1918 are embodied in "Studies in Yield and Reproduction of Western Yellow Pine in Arizona and New Mexico," by G. A. Pearson, Jour. Forestry, Vol. 16, No. 3, March, 1918, pp. 273–293. This study also formed the basis for Forest Service Circular 174, "Reproduction of Western Yellow Pine in the Southwest," by G. A. Pearson, 1910.

To be continued in connection with sample plot study, project Mc-2, and the study of forest types.

G. A. Pearson.

District 4.

(*e*) Douglas fir in central Idaho—Weiser and Payette Forests (Project Mr-1, D-4). Begun in 1910, when 10 plots, each 1 rod square, were laid out, the principal object being to study the effect of a good seed year on the reproduction of the succeeding year and the rate of drying out of the seedlings; plots counted twice in 1910 but not subsequently. In 1913, 23 plots 10 feet square were laid out on the Weiser and 34 on the Payette; and latter include 20 established by W. N. Sparhawk in connection with a grazing project, to determine extent to which Douglas fir is replacing yellow pine in the yellow pine type. The 34 Payette plots are mapped. Progress report by E. R. Hodson, 1913. In 1912–14, 131 other plots were established on the Payette in connection with the grazing project; these and the 30 seedling plots mapped in connection with the Mc-2 project afford data which may be used in this study.

Continuing. No work done since 1914.

Assigned to C. F. Korstian.

District 6.

(*f*) Douglas fir (Project Mr-1, D-6). Begun in 1913 with a detailed study of a 1902 burn on the Columbia Forest. A selected section was gridironed with east and west belt transects $8^1/_4$ feet wide and $2^1/_2$ chains apart, and the whole township then extensively studied by means of eight transects radiating from the section; area in transects; in the section, 372 acres; in the township, 1290 acres. This study established the principle that most of the reproduction that follows a simple burn is from seed stored in the forest floor before the fire and which retained its viability through the fire. Reproduction after compound burns studied in 1914 by transects in five areas on the Rainier Forest. Results embodied in comprehensive manuscript report on "The Management of Pacific Coast Douglas Fir" (three parts, 1917 and 1918), by J. V. Hofmann and C. J. Kraebel, and in "Natural Reproduction from Seed Stored in the Forest Floor," by J. V. Hofmann, Jour. of Agr. Research, Oct. 1, 1917, Vol. 11, No. 1, pp. 1–26. Nine plots, 1 rod square, were established in 1915, and reexamined in 1915 and 1916; 97 additional plots established in 1917, and others examined. In 1918 plots on 5 areas were reexamined, an 80-acre seed-tree tract located in the Wind River Valley, examination made of field tests of seed stored in the duff, and germination tests made in the nursery of stored seed from each station.

Continuing. Seed tree plots and after-cutting-reproduction plots to be initiated on the Oregon Forest.

Assigned to J. V. Hofmann.

Thinning

119. Effects of different degrees of thinning. To determine the comparative merits of different degrees and frequency of thinning on the growth of the remaining trees in a stand. Seven experiments are now under way in three Districts:

District 1.

(*a*) Western white, western yellow, and lodgepole pines, Douglas fir and western larch—Priest River (Project Mt-1, D-1). Work begun on Deerlodge Forest with yellow pine in 1911. In 1913 a series of $4^1/_2$-acre plots laid off in typical white pine-larch mixture at the experiment station and thinnings of different degrees made. Progress report April, 1914. Another series of plots established in white pine-larch mixture at the Experiment Station in 1914.

Continuing.

Assigned to investigative staff.

District 2.

(*b*) Western yellow pine—Black Hills (Project Mt-1, D-2). Begun in 1906 by Alfred Gaskill, who established nine plots in stands of different ages and densities, and thinned one. Some of these abandoned, others remeasured in 1912 and 1914. In 1909 three plots established, each 50′ × 100′ in size, representing three degrees of thinning; remeasured in 1914 and report submitted.

Continuing. Complete remeasurement to be made in 1919.

Assigned to C. G. Bates.

(*c*) Lodgepole pine—Medicine Bow (Project Mt-2, D-2). Begun in 1909, when eight plots were established, mapped, and variously thinned. Early work summarized in "Lodgepole Improvement Cutting," mss. report, 1911–12. Remeasured in 1914.

Continuing. Complete remeasurement to be made in 1919.

Assigned to C. G. Bates.

(*d*) Lodgepole pine—Medicine Bow (Project Mt-3, D-2). Begun in 1909, when three plots of $^1/_4$ acre each were established in a 30-year-old stand, mapped, and thinned. Partial remeasurement in 1912 (memorandum of Jan. 6, 1914). Complete remeasurement in 1914.

Continuing. To be remeasured in 1919.

Assigned to C. G. Bates.

(*e*) Lodgepole pine—Washakie (Project Mt-4, D-2). Begun in 1911, when three plots 100 feet square were laid out in 50-year-old lodgepole, and variously thinned. Remeasured in 1916.

Continuing. To be remeasured and stem analyses to be made in 1921.

Assigned to C. G. Bates.

(*f*) Douglas fir—Fremont (Project Mt-7, D-2). Initiated 1917.

Continuing.

Assigned to C. G. Bates.

District 4.

(*g*) Aspen—Great Basin (Project Mt-1, D-4). In 1912 four plots were laid out, of which two were transferred to project Fp-1. One plot thinned in 1913, the other in 1914. Seven additional plots established and thinned in 1914. Plots inspected and sprout reproduction recorded in 1917.

Continuing.

Assigned to C. F. Korstian.

MENSURATION

120. Volume, growth, and yield studies. To secure reliable data as to the growth, volume and yield of the different species and types of forest, as a basis for the proper handling of timber sales, management of the forests, and determination of damage caused by fire, trespass, etc. Particularly to standardize (1) the methods of collecting volume table data and (2) the form of the final volume table.

The work dates from the beginning of the Division of Forestry (1886) but has been most active within the last seven years. For 107 species there have been prepared 755 volume tables, 552 growth tables, and 80 yield tables, together with a large number of tables of form, height, etc. In addition, there were established over 300 permanent sample plots in nearly all the forest regions of the United States for the study of the growth and yield of stands.

Assigned to District investigative and local Forest staffs in cooperation with the Section of Computing, Washington office.

There are now 14 studies under way in seven Districts:

District 1.

(*a*) Douglas fir—Priest River (project ME-1, D-1). Progress report 1917.

Continuing.

(*b*) Lodgepole pine (project ME-2, D-1). Begun in 1912. Volume and yield data published in D. A. Bulletins 154 and 234. No work done in 1915–18. Deerlodge Forest and Dry Gulch Expt. Area.

Data will be gathered as opportunity offers in connection with other work.

(*c*) Western yellow pine (project ME-3, D-1). Begun in 1912, when 3,000 tree measurements were submitted for volume tables. Permanent plot established at Priest River, 1916. Volume table, Custer Forest, 1918.

Continuing.

District 2.

(*d*) Lodgepole pine (project ME-1, D-2). Volume study begun on the Arapaho and Medicine Bow in 1911, and Washakie in 1914. Local tables prepared for first two Forests. In 1915 a general board foot volume table, based on about 2,000 trees from the three Forests, was issued.

(*e*) Western yellow pine (project ME-2, D-2). Begun in 1911 on the Montezuma and later extended to the San Juan.

Project open for collection of data on larger trees.

(*f*) Engelmann spruce (project ME-4, D-2). Begun in 1912 and carried on on several Forests. A tentative volume table issued.

(*g*) Western yellow pine—Black Hills (project ME-5, D-2). Begun in 1914.

(*h*) Douglas fir—Pike, Rio Grande (project ME-6, D-2). Proposed in 1916, but little progress has yet been made.

District 3.

(*i*) Western yellow pine, Douglas fir, Engelmann spruce, white fir—Fort Valley and various Forests (project ME-1, D-3). Begun for yellow pine in 1911, Fort Valley. Proposed method of determining growth in uneven-aged stands found unsuitable for western yellow pine,

1913. Studies of the other species begun 1915. Volume table for Douglas fir constructed 1917, Alamo. Publication: "The Use of Frustum Form Factors in Constructing Volume Tables for Western Yellow Pine in the Southwest," by C. F. Korstian. Proc. Soc. Amer. Foresters, July, 1915, Vol. 10, No. 3, 301–14.

District 4.

(*j*) White, Douglas and Alpine firs, and Engelmann spruce (project ME-3, D-4). Begun in 1917 with study of rate of growth and yields, particularly with reference to association of these species with aspen.

District 5.

(*k*) Western yellow pine; second-growth in the Sierra Nevada (project ME-1, D-5). Begun 1913, when 33 sample plots were measured on the Tahoe, Sequoia, Sierra, and Stanislaus Forests, and about 85 complete stem analyses of sample trees made. Field work completed in 1914 and progress report submitted. Final report on "Characteristics and Yield of Second-Growth Yellow Pine in the Sierra Nevada," by W. H. Gallaher, submitted 1915. (See also under Tree Studies.)

Field work completed. Publication as a bulletin postponed pending further revision.

(*l*) Rate of growth of chaparral in southern California (project ME-3, D-5). Begun in 1912, Converse.

Final report under preparation.

District 6.

(*m*) Douglas fir (project ME-161, D-6). Three plots for study of growth of stands as affected by site and density, established 1910 on the Cascade; 4 in 1911 on the Siuslaw; and 8 in 1914 on the Columbia (3 of which were burned in 1915). Cascade plots remeasured 1915 ("Five years' Growth on Douglas Fir Sample Plots," by T. T. Munger. Soc. Amer. Foresters, Proceedings, Oct., 1915, Vol. 10, No. 4, 423–5), Siuslaw plots remeasured 1916 (manuscript report).

Cascade plots to be remeasured in 1915, the Siuslaw in 1921, and the Columbia in 1919. Additional plots will be established as opportunities arise.

(*n*) Sitka spruce, growth and yield—New (project ME-148, D-6).

121. Permanent sample plots (project ME-3, D-8; formerly Z-6, D-8, Special Studies). To obtain accurate figures on growth and yield, reproduction, and other silvicultural characteristics.

Establishment of permanent plots begun in 1904 under direction of H. S. Graves and George Hewitt Myers, and continued in 1905, 1906, 1913, 1914, and 1915. Periodic remeasurements, usually at 5-year intervals. Over 300 plots for study of growth, yield, and silvicultural features are now under observation, together with about 200 square rod plots for study of reproduction. Species studied include white, scrub, loblolly, shortleaf, and longleaf pines, spruce, cypress, mixed hardwoods, and mixed hard and soft woods. Plots in this project are located in New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia, South Carolina, Florida, Louisiana, and Arkansas. Plots in Connecticut, New York, Pennsylvania, Maryland, and part of those in New Hampshire and Vermont have been turned over to State and college agencies for subsequent remeasurement and observation.

Periodic remeasurements to be continued by the Forest Service and the States (in the cases in which the work has been transferred to them). The following bulletins are to be prepared in the Forest Service on the basis of past measurements: "The Growth of White Pine" and "The Growth of Loblolly Pine."

Assigned to W. D. Sterrett, W. B. Barrows, and State and College forestry departments.

122. Standardization of volume tables (project ME-7, D-1, 2, 3, 4, 5, 6, 7, 8).

Douglas fir tree measurements have been sent in to the Washington office by Districts 1, 2, 3, 4, 5, and 6. Preliminary work on the data from Districts 2, 3, and 5 has been done, and work is now under way for the other Districts. A comparison of the form quotients from different Districts indicates that while sizes differ the forms are so similar that data from several widely separated localities can be combined in one taper table, which can then serve as a basis for a "standard" volume table.

Taper tables for Douglas fir will be finished in accordance with the working plan, and other species of importance will be taken up one by one.

Assigned to W. B. Barrows, in cooperation with the Districts.

PROTECTION

Animals

123. Recuperation of different tree species from injury by grazing (project Pa-1, D-3). To determine definitely the time and character of the injury and the ultimate economic effect of the injury upon tree growth.

Work begun on Coconino in 1910. Additional records established in 1914 and 1915. Records have been maintained on saplings since 1914. These records are intended to supplement the more comprehensive study carried on by Mr. Hill under the Office of Grazing.

Continue records; plots to be reexamined every five years. The saplings measured in 1914 to be remeasured and rephotographed in 1919.

Assigned to officer in charge of the experiment station and local force on the Forest.

124. Control of rodents (project Pa-1, D-5).

Work begun in 1913. Poisons and traps set out on planting sites, but ineffective. Cooperation with the Biological Survey in winter of 1914 and during 1916. Effective measures worked out and plot of 80 acres established as a check. Reports on the pack rat and seed supply, and pack rat and natural reproduction submitted. Rats almost eliminated. Publication: "The Pack Rat as an Enemy of Natural Reproduction on the Angeles National Forest," by E. N. Munns. Jour. Forestry, April, 1917, Vol. 15, No. 4, 417–23.

Discontinued with the abandonment of the Converse Experiment Station.

Data being compiled.

Assigned to E. N. Munns.

Diseases

125. Causes of tree diseases and methods of prevention and control. (See also the projects listed under Bureau of Plant Industry, Investigations in Forest Pathology.)

Many fungi responsible for the decay of the different species have been discovered and described. The following 14 studies under the direction of Dr. James R. Weir, Forest Pathologist are now under way:

District 1.

(*a*) Diseases of western white pine (project Pd-2, D-1). Begun 1912.

(*b*) Diseases of western hemlock, grand fir, alpine fir (project Pd-3, D-1). Begun 1911. Publication: "A Study of Heart-rot in Western Hemlock," by J. R. Weir and E. E. Hubert, Dept. of Agr. Bulletin 722, 1918; "The Influence of Thinning on Western Hemlock and Grand Fir Infected with *Echinodontium tinctorium*," by J. R. Weir, Jour. Forestry, Jan. 1919, Vol. 17, No. 1, 21–35; Mss. report: "Some Considerations Pertaining to the Diseases of Western Hemlock and Grand Fir as Affecting Forest Management," by J. R. Weir, 1914.

(*c*) Diseases of western red cedar (project Pd-4, D-1). Begun 1914. Publication: "*Keithia Thujina*, the Cause of a Serious Leaf Disease of the Western Red Cedar," by J. R. Weir, Phytopathology, Aug. 1916, Vol. 6, No. 4, 360–3.

(*d*) Diseases of Lodgepole pine (project Pd-5, D-1). Begun 1915.

(*e*) Diseases of western larch (project Pd-8, D-1). Begun 1915.

(*f*) Forest tree rusts (project Pd-6, D-1). Begun 1916. Publication by J. R. Weir and E. E. Hubert in Phytopathology: "Recent Cultures of Forest Tree Rusts" and "Pycnial Stages of Important Forest Tree Rusts," April, 1917, Vol. 7, No. 2; "Notes on the Overwintering of Forest Tree Rusts," Feb. 1918, Vol. 8, No. 2; "Notes on Forest Tree Rusts," March 1918, Vol. 8, No. 3. In Amer. Jour. Bot.; "Observations on Forest Tree Rusts," June, 1917, Vol. 4, 327–35.

(*g*) False mistletoe (project Pd-7, D-1). Begun 1916. Publications by J. R. Weir: "Mistletoe Injury to Conifers in the Northwest," Dept. of Agr. Bulletin 360, 1916. "Larch Mistletoe," Dept. of Agr. Bulletin 317, 1916. "Some Suggestions on the Control of Mistletoe on the National Forests of the Northwest," Forestry Quarterly, Dec. 1916, Vol. 14, No. 4, 567–577.

(*h*) Forest tree disease surveys (project Pd-9, D-1). Begun 1916. Publications: "Forest Disease Surveys," by J. R. Weir, U. S. Dept. of Agr. Bulletin 658, 1918.

District 3.

(*i*) Effect of mistletoe on growth and seed production of western yellow pine (project Pd-3, D-3). Begun 1910. Progress reports 1913, 1914, and 1915. Report on "Effect of Mistletoe on the Growth of Western Yellow Pine," by W. H. Long and C. F. Korstian, 1917.

Continuing.

Assigned to Ft. Valley Experiment Station in cooperation with Dr. W. H. Long, District Pathologist.

(*j*) Decadence of mature western yellow pine (project Pd-4, D-3). Begun 1910. Progress reports, 1913, 1914.

Continuing.

Assigned to Ft. Valley Experiment Station.

(*k*) Study of heart rots in connection with timber sale practice (project Pd-5, D-3). Begun 1914. Progress report 1915.

Continuing.

Assigned to Dr. W. H. Long.

District 5.

(*l*) Pathological investigations (project Pd-2, D-5). Begun 1914. Progress report 1917. Publication: "Forest Pathology in Forest Regulation," by E. P. Meinecke, Dept. of Agr. Bulletin 275, 1916.

Continuing.

Assigned to Dr. E. P. Meinecke, Forest Pathologist.

District 6.

(*m*) Damping off (project Pd-1, D-6). Begun 1916. Progress report 1917.

Continuing.

Assigned to investigative staff.

(*n*) Pathological study of Douglas fir on the Cascade Forest (project Pd-161, D-6). Begun 1917. Progress report 1917.

Continuing.

Assigned to Dr. E. P. Meinecke and D-6 investigative staff.

Fire.

126. Development of a scientific basis for rating forest fire hazard and liability (project Pf-1, D-1, 2, 3, 4, 5, 6, 8).

Tentative method for rating hazard and liability drawn up on basis of detailed study of records in Districts 1 and 6. Collection of detailed individual fire reports undertaken in all Districts. Work interrupted by the war.

Detailed study of records in the other Districts, and preparation of final scheme for rating fire danger. Collection of detailed reports on individual fires to be continued in all Districts as basis for revision of ratings in future.

Assigned to W. N. Sparhawk in cooperation with District officers.

127. Relation of meteorological conditions to forest fire hazard and fire protection, with especial reference to the prediction of danger periods and the behavior of fires under given conditions (project Pf-2, D-1, 2, 3, 4, 5, 6, 8).

General survey of weather conditions in the different Districts made, and National Forest area tentatively divided into climatic groups; tentative specifications of dangerous weather conditions drawn up for use of Weather Bureau in forest fire warning service. Experiment stations in several Districts have collected data on relation between inflammability and weather conditions. Studies of rate of spread carried on for two years at Feather River Station. Work interrupted by the war.

Data to be obtained where possible in connection with fire hazard study.

Assigned to W. N. Sparhawk and Experiment Stations in Districts 1, 2, 3, 5, 6.

128. Principles underlying methods of fire protection (project Pf-3), all Districts.

Considerable administrative work has been done in all Districts in developing special equipment. Some studies, such as lookout problems, made in several Districts.

Continuing.

Assigned to District and Forest officers.

129. Light burning (project Pf-3 (*b*), D-5). To determine the real value of light burning as a protective measure, the cost and its effect upon the cash value of merchantable and potentially merchantable timber, and on the future of the forest.

Experimental burning done on suitable areas in 1911, and observations and further experiments in subsequent years. Publication: "Light Burning at Castle Rock," by S. B. Show, Proc. Soc. Amer. Foresters, October, 1915, Vol. 10, No. 4. Study of light burning in relation to insect infestation made. Progress report on later work in preparation.

Continuing.

Assigned to S. B. Show.

130. Smoke visibility (project Pf-3 (*c*), D-6). To determine (1) distance at which small fires may be seen and how affected by size of fire, atmospheric and other conditions; (2) distance below range of observer's vision at which fires may be seen under different conditions; (3) relative visibility from high mountain (10,000 ft. or more) and ordinary (5000–7000 ft.) lookouts.

Begun in 1917.

Continuing.

Assigned to District office.

131. Determination of relative amounts of fire damage in different types of forest in different regions (project Pf-4, D-6).

Study of extent of damage and recovery of injured trees in yellow pine type made on Deschutes Forest in 1915–16. Examination made in 1917.

Continuing.

Assigned to District and Forest officers.

132. Elimination of static electricity from grounded telephone wires (project Pf-7, D-8).

Begun as a project in 1916, after some preliminary studies had indicated probable source of static. A telephone line was chosen for study and a topographic map made of entire route. Tests made in 1917 developed equipment by means of which static was absolutely reduced on the experimental line about 50 per cent, without interference with service. Progress report 1917.

Continuing 1–2 years.

Assigned to R. B. Adams, Telephone Engineer.

Insects

133. Silvicultural methods for the control of the gypsy and brown-tail moths (project Pi-1, D-8).

Begun in 1913. Twenty-nine sample plots established. Publication: "Control of the Gypsy Moth by Forest Management," by Willis Munro, Dept. Agr. Bulletin 484, 1917.

The sample plots are to be reexamined periodically. In some cases seedlings will need further assistance by the removal of sprouts. Large trees left should in some cases be removed as soon as desired young growth has established itself beneath them.

Assigned to Forest Service, in cooperation with Bureau of Entomology, W. Munro in charge.

TREE STUDIES

134. **Western white pine (project TS-1, D-1).** Preparation of monograph bulletin.

Begun as a project in 1912. Up to and including 1912, over 4000 tree measurements for volume, and 230 plot measurements for yield had been secured on five Forests. Report on "Western White Pine Seed Distribution" submitted by Mr. Brewster in 1913. Field work on project practically completed in 1913 and preliminary draft of bulletin by F. I. Rockwell submitted 1914. Supplementary field work done and data compiled in 1914–15. Second draft of bulletin submitted 1917. Publication withheld until studies of other phases of the management of western white pine are made. Publication: "Growth of Western White Pine and Associated Species in Northern Idaho," by J. A. Larsen, Jour. Forestry, Nov., 1918, Vol. 16, No. 7, 839–40.

Publication of bulletin postponed for addition of material on other phases of management, for which further field work is required.

135. **Western larch (project TS-2, D-1).** To secure data on the characteristics, distribution, growth, yield, management, and uses of western larch.

Begun as a project in 1916, although data collected in connection with previous projects were utilized. A yield study on the Blackfeet Forest was completed in 1917. Progress report 1917. Publication: "Silvical Notes on Western Larch," by J. A. Larsen, Proc. Soc. Amer. Foresters, Oct. 1916, Vol. 11, No. 4, 434–40.

One year's work remains to be done, but assignment is indefinite.

136. **Jack pine (project TS-4, D-2).** Bulletin on economic and silvicultural importance and management.

A large amount of data secured before 1911 in extensive studies in the Lake States, by L. L. White, H. H. Chapman, J. St. J. Benedict, and others. Further field work in the Lake States, by W. D. Sterrett, 1917. Dept. of Agr. Bulletin entitled "Jack Pine," by W. D. Sterrett, in press.

Completed. Publication pending as Dept. of Agr. bulletin.

Assigned to W. D. Sterrett.

137. **Silvical leaflets (project TS-10, D-8).** To bring together in brief form the available silvical information regarding American forest trees.

Begun in 1907. Silvical leaflets for 53 species have been published. Material available for 16 additional species. No leaflets prepared in 1913–18.

Additional leaflets to be prepared on basis of material on hand. Publication by groups of species, as farmers' bulletins, under consideration.

Assigned to Washington office in cooperation with the Districts.

138. **Oaks of the eastern United States (project TS-12, D-8).** Bulletins on the economic and silvicultural importance of the different species of oak as a basis for management.

Begun in 1916. Field work completed in 1917. First draft of bulletin on "Utilization of Oak," completed in 1919.

Silvicultural bulletin on the oaks to be prepared in 1920.

Assigned to W. D. Sterrett.

139. **Black walnut (project TS-302, D-8).** Bulletin on distribution, silviculture, and management.

Field work done by F. S. Baker in 1918, in connection with study of production of black walnut timber for war use. Report on "Black Walnut: Its Growth and Management," prepared by Mr. Baker for publication as a Dept. of Agriculture bulletin.

Completed. Publication pending as Department of Agriculture bulletin.

Assigned to F. S. Baker.

140. **Western yellow pine (project ME-1, D-5).** Second growth yellow pine in the Sierra Nevada (see also under Mensuration).

Begun as an ME project in 1913. Field work completed 1914 and progress report submitted. Final report on "Characteristics and Yields of Second-grown Yellow Pine in the Sierra Nevada," by W. H. Gallaher, submitted 1915.

Publication of report as a bulletin postponed pending further revision.

Assigned to S. B. Show.

TYPES.

141. **Meterological study of forest types (project T-1, D-1, 2, 3, 5).**

District 1.

(*a*) Begun 1911, completed 1916. Final report on "Climatic Study of Forest Types," by J. A. Larsen, submitted 1918.

Assigned to J. A. Larsen.

Completed.

District 2.

(*b*) Begun as a project in 1914 in cooperation with the Weather Bureau, although actually a continuation of old project M-1, 1910–12. Final report on "Forest Types of the Central Rocky Mountains in Relation to Environmental Conditions," by C. G. Bates, submitted 1919. Publication: "Climatic Characteristics of Forest Types in the Central Rocky Mountains," by C. G. Bates. Proc. Soc. Amer. Foresters, Jan., 1914, Vol. 9, No. 1, 78–94.

Assigned to C. G. Bates.

Completed.

District 3.

(*c*) Begun 1916. Instruments installed at four stations, at which climatological and phenological records have been carried on continuously. Soil moisture samples taken monthly through the growing season of 1918, and sent to Bureau of Soils for chemical and mechanical analysis. In 1918, plants of nearly all conifers of the San Francisco Mountains were potted and records begun on relative rate of water loss of different species and of same species on different sites; also effect of soil upon root development and moisture requirement. Experimental planting of all the species in all the forest types. Report on

"Factors Controlling the Distribution of Forest Types," by G. A. Pearson, submitted 1919. Publication: "A Meteorological Study of Parks and Timbered Areas in the Western Yellow Pine Forests of Arizona and New Mexico," by G. A. Pearson. Monthly Weather Review, Oct., 1914, No. 10, 1615–29.

Instrument records to continue until December 31, 1919. Intensive plant studies to concentrate upon western yellow pine. Study to be directed as soon as possible to solution of problems of forest management as applied in marking policies. Preliminary report now in preparation.

Assigned to G. A. Pearson.

District 5.

(*d*) Begun in 1913, when three meteorological stations were established between 2700 and 7400 feet elevation; these discontinued in 1914, with exception of the station at 2700 feet, and four new established on south slopes at 4000, 5000, 6000, and 7000 feet. In 1915 corresponding north slope stations established. Porous cup atmometers operated at each station. Observations of air and soil temperature and weekly soil moisture determinations made at each station. The station at 2700 feet discontinued in 1916. Data are now being compiled.

Additional field work to be done and final report made in 1919.

Assigned to E. N. Munns.

142. Bear clover (project T-2, D-5) and brushfield (project T-3, D-5) types. To determine extent and distribution of bear clover and brushfields of northern California, their cause, composition, and characteristics; value and use, if any; effects of fire and grazing; character and rate of replacement by timber through natural reproduction; and possibilities of encouraging or securing reproduction of commercial tree species by artificial means.

(*a*) Bear clover.

Begun on the Eldorado, Sequoia, and Stanislaus Forests in 1912. Publication: "Bear Clover," by J. A. Mitchell, Jour. Forestry, Jan., 1919, Vol. 17, No. 1, 39–43.

Assigned to J. A. Mitchell.

Completed.

(*b*) Brushfields.

Begun on the Klamath Forest in 1910, Trinity 1911, Lassen and Shasta 1912, and California, Eldorado, Plumas, Tahoe, and Sierra 1913. Final report, "The Brushfields of California," by S. B. Show, submitted 1919. Publication: "Reforestation of Brush Fields in Northern California," by R. H. Boerker. Forestry Quarterly, March, 1915, Vol. 13, No. 1, 15–24.

Assigned to S. B. Show.

Completed.

143. Forest regions of the United States (project T-2, D-8). (Formerly project Z-1, D-8.)

A map showing natural forest units has been prepared and will be published, with descriptive text, by the Office of Farm Management, as a part of the Agricultural Atlas series.

Project will be closed with the publication of the map.

Assigned to Raphael Zon.

INVESTIGATIONS AT THE FOREST PRODUCTS LABORATORY

MECHANICAL AND PHYSICAL PROPERTIES AND STRUCTURE OF WOOD

Mechanical properties

144. Mechanical properties of woods grown in the United States (project L-124.

The broad project of determining the mechanical properties of woods grown in the United States has been under way for some 15 years. Over 500,000 tests have been made on some 130 species. Such tests form a basis for the comparison of species, the choice of species for particular uses, and for the establishment of correct working stresses. Approximately 150,000 of the 500,000 tests had as their primary object the comparison of the properties of American woods (L-124), about 200,000 the determination of the best methods of kiln drying species particularly for aircraft use (L-221), and the remaining 150,000 included studies of plywood (L-225), studies of the effect of preservative treatment on strength (L-7), tests of airplane parts and other commercial forms, cross-grain investigations (L-228-4), etc. About two-thirds of all mechanical tests made can be used for the purpose of comparing the properties of species. During 1917, 1918, and the first half of 1919 a total of 8770 tests were made. Of these 5834 were on green material and 2936 on air-dry material. The following species were tested:

Honey locust
California black oak
California laurel
Black walnut
Lodgepole pine
Blue gum
Canyon live oak
Madrona
Western black willow
Pale elder
Goldenleaf chinquapin
Cascara buckthorn
Pacific dogwood
Common cottonwood
Pecan (hickory)
Persimmon
Sugarberry
Black willow
Tupelo (cotton gum)
Aspen
Limber pine
Mexican walnut
Pinon
Gambel oak
Alligator juniper
Alligator pine
White fir
White elm
Red oak
Redwood
Red fir

Practically all applicable project L-221 data obtained to date has been resummarized for use in project L-124. A number of publications have been issued, the most inclusive being U. S. Dept. of Agr. Bulletin No. 556, "Mechanical Properties of Woods Grown in the United States."

Tests are now under way on air-dry redwood and red fir. Tests will also be made on the following species: mangrove, blackwood, Florida buttonwood, mastic, gumbo limbo, pigeon plum, Paradise tree, inkwood, black ironwood, garber stopper, golden fig, fustic, poisonwood, Cuban pine, apple, and such other species upon which we have no data, as opportunity offers for the collection of material. Summarize applicable project L-221 data as this becomes available. But little additional time will be required for this work. Miscellaneous: Prepare manuscript for publications as follows:

"Factors Influencing the Strength Tests of American Woods," "The Influence of Position of Growth Rings on the Strength of Spruce."

145. Tests to determine the strength of wooden beams under continuously applied loads (L-14).

A series of tests on longleaf pine have been completed and the data partially analyzed.

Analysis of the data and preparation of report. A working plan for an additional series of tests will be prepared and if possible work will be continued.

146. Strength of timbers in structural sizes with special attention to grading rules. Strength tests of longleaf pine in structural sizes (L-184).

A large amount of testing on structural timbers of the various qualities commonly found on the market has been done for the purpose of establishing grading rules. These data in conjunction with the tests made on small clear specimens furnish a basis for determining safe values for use in designing timber structures. Grading rules for structural timbers of our two most important coniferous species, southern yellow pine and Douglas fir, have resulted primarily from these tests and studies, and have been adopted by lumbering and engineering associations. A number of articles and bulletins have been published, including Forest Service Bulletin No. 108, "Tests of Structural Timbers." Testing work both on large timbers and on minor specimens cut from them has been completed and the data have been analyzed.

Complete report or article for publication.

147. Strength tests on Alaskan grown timbers in structural sizes (L-189).

Several mine props and caps tested. If Alaskan grown timbers prove suitable for mine use the necessity of shipments from the Northwest will be obviated.

Twelve air-dry timbers and 480 minors of Alaska spruce are to be tested.

148. Tests of green and air-dry Douglas fir bridge stringers to be graded by the New Grading Rules for Douglas Fir (L-197).

Working plan written and several tests made on stringers. These tests will show how the density rule for Douglas fir timbers checks with the actual strength of the timbers. This is an extension of the series of tests on Douglas fir timbers of structural sizes.

Collect material and make tests on approximately 74 stringers and 1776 minors.

149. Strength tests of hemlock in structural sizes (L-211).

Material collected and tests on green material completed. Tentative grading rules prepared on basis of tests made.

Tests to be made on air-dry material, final grading rules to be formulated, and report to be prepared. Miscellaneous: Construct and perfect machine for determining proportion of summerwood in southern yellow pine and Douglas fir.

150. Building codes with reference to timber for structural purposes.

Previous investigations of building codes have shown a wide variation in the working stresses allowed for the same structural timbers in various cities. Milwaukee, Minneapolis, and St. Paul have been visited, and architects, engineers, and city officials consulted concerning the use of timber and building codes. Tables of safe design figures have been prepared for the use of engineers and architects and have been incorporated in the building codes of many cities.

Visit important cities of the United States and compile reports and suggestions.

151. Effect of commercial preservative processes on the strength of structural timbers (L-7).
One series of tests has been made on southern yellow pine and several on Douglas fir. Tests have recently been completed on green Douglas fir stringers treated by a new process developed on the Pacific Coast. Bulletin and several articles published.

The 4″ × 16″ × 4′8″ Douglas fir timbers treated by the boiling process which are now seasoning at the Madison Laboratory are to be cut up into minor specimens and tested. A report on the work will be prepared.

152. Douglas fir (L-7a and 7c).
Considerable data have been collected on both the steaming and boiling processes.

(1) Steaming process. Make tests on 30 air-dry timbers 8″ × 16″ × 16′ (natural and treated) and 750 minors; (2) boiling process. Make tests on 32 air-dry timbers 8″ × 16″ × 16′ (natural and treated) and 768 minors.

Assigned to Seattle Laboratory.

153. Tests of poles (L-31a, 31b, and 31c).
All tests complete. Bulletin published. Final report in progress will cover all major and minor telephone pole tests made by the Forest Service.

Complete report.

Assigned to Seattle Laboratory and Forest Products Laboratory.

154. Utilization of National Forest timbers (L-215).
Western yellow pine and white fir railroad ties obtained from the Atchison, Topeka & Santa Fe Railroad Company have been tested.

Complete analysis of test data and prepare report on tests and inspection trip for District 3.

Assigned to Forest Products Laboratory.

155. Effect of defects on the mechanical properties of wood. Limits of spiral grain: Influence of spiral grain on strength properties (L-228-4).
Reports prepared giving results of tests on kiln-dry Sitka spruce and Douglas fir. This project applies especially to airplane stock. It was found that several members could contain certain defects properly placed without loss in strength. Cooperation with the Bureau of Construction and Repair. Effect of advance decay and discoloration by wood-rotting fungi on the mechanical properties of airplane wood (L-243).

Bureau of Plant Industry, Investigations in Forest Pathology, cooperating with the Forest Products Laboratory, conducted tests on woods used in airplane construction at the testing laboratory of the University of California.

Prepare working plan for tests on ash. Conduct investigation and write report, and possibly article for publication giving effect of cross grain on strength of ash. Review manuscript to be prepared by Bureau of Plant Industry, Investigations in Forest Pathology on investigation. Miscellaneous: Prepare manuscript for publication showing the effect of cross grain on the mechanical properties of Sitka spruce, Douglas fir, and white ash, when tests of latter are completed.

156. Vibration and fatigue tests of wood (L-229).

A few preliminary tests were made under project (L-225–1) in which the wood fibers were subjected to reversals in stress. A machine is nearly completed and preliminary experiments are under way to determine the laws governing the natural period of vibration of wood. This preliminary work is a prerequisite to studying the effect of vibration on the mechanical properties.

Complete preliminary tests to determine most satisfactory method of testing. Prepare working plan, conduct investigation, and write report on effect of vibration on strength.

157. South American woods

Tests on a few South American woods have been completed and a preliminary summary of the data has been made. The air-dried specimens have been examined and the soaked specimens are being examined for decay. A very high percentage of the material is decayed and will not afford reliable strength data.

Complete examination of soaked specimens and record this information with the strength data. It may be found desirable to resummarize the strength data so as to eliminate the results obtained on decayed specimens. Additional work on South American woods is desirable.

158. Influence of drying and steaming on the strength of wood (L-221).

Influence of drying and steaming on the strength of airplane stock (L-221–1).

The specifications for kiln drying airplane stock prepared for the Army and Navy are based largely on the results of tests made under this project (L-221–1). (*a*) Tests were made on the following species: sugar maple, white fir, Douglas fir, white pine, western white pine, Norway pine, bald cypress, eastern spruce, Sitka spruce, noble fir, Port Orford cedar, western yellow pine, yellow birch, black walnut, red gum, African mahogany, Central American mahogany, and yellow poplar. The effect of kiln drying on the strength of airplane woods published as Report No. 68 of the National Advisory Committee for Aeronautics. A number of articles also published. (*b*) Additional material of the following species is available in log form: Douglas fir and bald cypress. This work has been in cooperation with the War and Navy Departments.

L-221–1 (1) Complete reports on work under (*a*).

(2) Make four kiln runs on bald cypress and three kiln runs on Douglas fir.

(3) Test kiln-dried cypress and Douglas fir and also the corresponding matched green and air-dried material. Conduct tests under this project on white ash to be kiln dried for project L-228–4, if possible.

(4) Complete reports embodying results of tests to determine effect of kiln drying on strength.

159. Effect of moisture on mechanical properties of wood (L-240).

Research begun in cooperation with Yale Forest School. Results published in Forest Service bulletin 70 and Circular 108. This work included several species and several properties, but needs to be extended to numerous other species and especially to such properties as drop in impact and work values in static bending. From a recent review of data an equation between moisture and strength has been derived which seems to represent a fundamental natural law. If this equation proves to be applicable to all species and properties the value of project L-124 will be greatly enhanced.

A study of moisture relations for all strength properties and for a few additional species as well as the determination of the fiber saturation point for all species should be undertaken. Tests on redwood which are now under way will be completed and a report prepared.

160. Bent forms. (*a*) Methods of bending and their influence on strength (L-234).

Relatively large stock (vehicles). Two brief reports prepared based on field study of bending of heavy rims. Apparatus for steaming, boiling, and bending installed and some tests completed on red and white oak.

Report on experiments in bending red and white oak vehicle stock to be completed. A general study should be made of fundamental factors involved in bending heavy or light stock to a severe or moderate extent in order to secure a minimum loss of strength and maximum ability to retain form. Information is needed as to methods of severe bending of material such as artillery rims and more moderate bending such as airplane longerons, as well as a study of methods of bending coniferous woods such as spruce and Douglas fir.

Relatively small stock. Tests on commercial white ash and spruce made to secure preliminary data in connection with the bending of airplane stock such as longerons. A report was issued giving results of these tests.

(*b*) Bending tests of special forms (L-231).

(*c*) Plywood bent forms. Methods of bending (L-225–6).

This project largely in cooperation with War Department.

161. Strength tests. Built-up beams (L-4).

Eleven 8″ × 12″ × 16′ bolted beams were made up of 2″ clear southern yellow pine. These beams, including 1210 minor tests, have been tested and the data have been tabulated. These tests were made in cooperation with the National Lumber Manufacturers' Association. Investigations of built-up construction become more and more important with the increasing difficulty of securing material of satisfactory quality in large sizes.

Complete report on these tests. Additional work on built-up beams desirable.

162. Tests on mechanical efficiency of joints and fastenings in wooden structures (L-9).

Four beams were built up of $2^1/_2$″ × 16″ × 16′ southern yellow pine members and tested.

Complete report of work.

163. Plywood study (L-225). The following series of plywood investigations is conducted in cooperation with the Army and Navy:

(*a*) Strength tests of plywood (L-225–1).

Strength tests have been made of 35 species. These tests supplied information on the variation in strength of different combinations of species, number of plies, and ratio of core to total plywood thickness. Information regarding causes and prevention of the warping of plywood, its bearing strength, and shrinkage, are available but to a more limited extent. Several reports have been published and an exhaustive report is under preparation.

Working plan to be prepared and tests conducted to determine toughness of plywood, and report to be written. Material for this work now on hand.

Warping tests of plywood. Working plan to be prepared, investigation conducted, and report to be written.

Stiffness of plywood in different directions. Working plan to be prepared, investigation conducted, and report to be written.

(*b*) Strength tests of built-up plywood forms (L-225–2).

Many tests have been made on built-up plywood forms such as airplane engine bearers, wing ribs, and elevator spars. A limited number of tests have been made on plywood as a substitute for linen airplane covering. Several reports have been published.

DeH-4—A DeH-4 airplane wing to be designed, constructed, and tested, using woven plywood. Report to be written.

MF—Plywood for two MF wings to be secured and applied. Covering to be finished with varnish and aluminum leaf, and sent to Naval Aircraft Factory for weathering tests.

DeH-4—Sections of plywood wing to be coated with varnish and aluminum leaf. Weathering test to be conducted and report written.

(*c*) Strength tests of plywood fastenings (L-225–4).

Screw fastening tests completed to determine length and size of screws, as well as spacing and margin for 3-ply wood. Report to be completed.

Plywood bearing—Some tests completed on various series of plywood. Report to be completed.

Manuscript to be completed for publication on the "Mechanical and Physical Properties of Plywood."

164. **Aircraft study (L-228).** This study is being conducted in cooperation with the War and Navy Departments.

(*a*) Strength tests of airplane struts (L-228–1).

Tests have been made on several types of airplane struts. Entirely new and easily applied methods of testing have been developed for use in making inspection tests.

Data to be analyzed from tests of struts of rectangular cross section. Series of streamline tapered struts to be prepared and tested, report to be prepared, and article for publication. Development of Thelen strut to be continued, conducting tests with different end conditions and with streamline members; on completion of development, report to be prepared, and article for publication. Working plan to be prepared and tests conducted on both tapered and untapered fuselage struts with varying ratios of L/r, and report and article to be written for publication.

(*b*) Specifications for airplane parts (L-228–2).

Specifications for Army and Navy to be reviewed and prepared as required.

(*c*) Strength tests of airplane wing beams (L-228–3).

Tests have been made on quite a number of different types of wing beams, and among other things have shown the possibility of built-up and laminated construction for use under most exacting requirements. Apparatus has been designed and constructed for combined loading tests of a U. S. D-9 wing beam. Tests have also been made on dirigible girders. Several reports have been published.

The tests of the U. S. D-9 wing beam and the dirigible girders are to be completed and reports prepared. For the girders, redesign and continue the investigation if necessary; report to be prepared for the Navy. Box beams for maximum strength and stiffness to be designed, using developments of plywood investigation in construction of cheek pieces; a working plan to be prepared, tests conducted, and report written.

Manuscripts are to be completed for publication entitled "Tests on Airplane Parts" and "Wood in Airplane Construction."

165. Tests of manufactured articles (L-248).

(*a*) Mechanical tests on doors (L-248–1).

Mechanical tests on 48 doors of three different types were completed and warping tests on 24 other doors are practically completed.

Report to be completed on these tests. A further series of tests on different types of joints commonly used in door construction should be made.

(*b*) Development of a box testing machine and methods of testing boxes (L-207).

A box testing machine has been developed consisting of a large, hollow, hexagonal drum in which the boxes to be tested are placed. When the drum is rotated the boxes are tumbled about, striking on their corners, edges, sides, etc. By means of this machine the relative strength of various designs can be shown.

Additional testing machines will be developed if found necessary.

(*c*) Tests on packing boxes to determine the relation of thickness of material, kind of wood, strapping, etc., to the size of box and weight of contents (L-207–3).

Tests have been under way for the past seven or eight years on a large number of types of boxes for widely varying uses. Tests during the war were made almost entirely for the War Department. These tests have yielded preliminary data of great value on the general relationships which are the purpose of the project. A large number of articles have been published and a long manuscript entitled "Manual of Wooden Box and Crate Construction" has been completed for publication.

Tests will be continued with particular reference to the development of general laws which will be applicable to specific questions of container design and specifications. The box and crating manual will be published as soon as possible.

(*d*) Tests on fiber and corrugated shipping containers for the improvement of design (L-207–4).

Certain phases of this work are financed by the Ordnance Department. A comparatively limited number of tests has been made on fiber and corrugated shipping containers. Progress reports have been written.

This work will be continued as opportunity offers.

(*e*) Resistance of various species of timber to the withdrawal of nails (L-9*a*).

An article entitled "Tests made to Determine the Lateral Resistance of Wire Nails" was published in the Engineering News Record. No tests have been made on this project for several years. Nail pulling tests were made on hemlock, shipments L-435 and L-436.

Resistance of various species of timber to the withdrawal of nails (L-9*a*) (continued).

Work called for in plan to be completed as opportunity offers, including tests on splices and additional tests on crushing, splitting, and shearing effect of bolts. Report to be completed on tests already made. Tests to be made as opportunity may offer on additional species. Tests ultimately to include all species collected under Project L-124.

Physical properties

166. Fundamental laws of drying wood (L-134).

Investigations of various phases of the laws of drying wood have been under investigation for the past 15 or 20 years and have resulted in numerous articles and bulletins. Much of the work under the following project, "The kiln drying of various species of wood," has aided in the development of fundamental drying laws.

(*a*) Investigation has been outlined and two years' work done on the rate of transfusion of moisture through wood and influences that might increase it. Discontinued during war.

(*b*) Some work has been done on the effect of preliminary treatment upon subsequent drying and working of wood, and a progress report has been written.

Three reports will be written under this project prior to July 1, 1920. Work on "Fundamental Factors Affecting Shrinkage," "Comparative Rates of Drying in the Three Coordinate Directions of Various Species," and similar problems will be undertaken as soon as possible.

Work already done, as outlined under (*a*) above, will be assembled in form of a progress report.

Work, as outlined under (*b*) above, will be reviewed and progress report prepared. Additional work will be initiated.

167. Experiments in kiln drying different species of wood (L-142). Army or Navy funds are used as the work requires.

Work under this project has resulted in the development of a dry kiln in which it is possible to regulate closely temperature, humidity, and circulation, the factors on which satisfactory drying depends. Two types of this kiln, one adapted to slowly drying refractory hardwoods, the other to rapidly drying softwoods, have been invented and patented for the free use of the public. A great deal of progress has been made in working out proper methods of drying for the several species of hardwood and coniferous timbers. A large number of articles and bulletins covering the results of the work have been published.

This study now includes various phases of kiln drying as indicated in detail under the following headings:

(*a*) Six kiln runs have been made on heavy oak and hickory vehicle parts in cooperation with large manufacturers, resulting in information which has been used in cooperation with about 24 manufacturers in the drying of green oak stock at their plants. A shipment of 29 southern swamp oak logs has been received for further experimental work at the Laboratory.

Four additional runs will be made in laboratory kilns to determine treatment required for successfully drying the more refractory species of oak, checking of recommended schedule, and possibilities of increasing drying rate. Further cooperation will be undertaken with vehicle manufacturers in improving present commercial practice.

(*b*) Six inspection trips have been made to ascertain typical commercial methods of seasoning various wooden products.

A definite policy of cooperation will be drawn up with representative concerns in the study of different types of commercial kilns with the view of definitely determining the possibilities and limitations of each type for a given class of drying. One kiln run will be made under commercial conditions in each of three types of kilns—ventilated, blower, and condenser. Actual figures will be collected as to both costs and losses involved in the ordinary practice of air-seasoning as compared with kiln drying.

(*c*) Kiln runs have been made on sugar pine, Douglas fir, red fir, white fir, ironwood, wild lilac, and dogwood.

Reports will be completed on these species. Additional study will be made of kiln drying miscellaneous hardwoods as occasion demands.

(*d*) Preliminary study has been made of the comparative efficiency of the water spray and steam jet condenser kiln in heat consumption in connection with kiln drying.

One additional progress report will be added to complete the investigation.

(*e*) Ninety-eight kiln runs have been made on various species under consideration for airplane construction to assist in the determination of the effect of kiln drying on the mechanical and physical properties. Five inspections have been made at airplane factories to ascertain practices. One publication prepared for the National Advisory Committee for Aeronautics.

Additional kiln runs will be made on yellow poplar and Philippine mahogany. One publication for aeronautical journals entitled "The Drying of Propeller Woods" will be prepared during the year.

(*f*) Two inspections have been made of common practice of seasoning artificial limb stock at request of Surgeon General, U. S. Army. Reports thereon added to files. Shipment of willow blanks to laboratory from cooperating firm for experiments in kiln drying. Two kiln runs completed.

One kiln run will be made to complete tests in the laboratory kilns and a final report will be written on the investigation.

(*g*) The study of kiln drying of treenails originated in a request from the Emergency Fleet Corporation and as a result of a field study of wood shipbuilding practice. Two reports have been prepared, one of which was submitted to Emergency Fleet as preliminary recommendation. The Emergency Fleet Corporation furnished a carload of live oak squares to kiln dry experimentally.

Two kiln runs on live oak squares will be made and a final report made to Emergency Fleet Corporation.

(*h*) Laboratory test made of possibility of closing surface checks in bent chair stock by subsequent drying and steaming treatments.

Laboratory report will be prepared.

(*i*) One kiln run made in Laboratory kiln in cooperation with chair manufacturer who has dried matched material according to his usual practice in his commercial kiln to determine effect of kiln drying on color of oak chair stock.

Report will be prepared bringing together the comparative results of the two runs.

(*j*) Material representing nine important Brazilian hardwoods received at Laboratory from Department of Commerce. One preliminary kiln run has been completed.

Three more kiln runs will be made and a report prepared.

(*k*) Plans, tables, and figures to assist engineers in the proper design of the water spray kiln for various commercial requirements are being prepared.

This information will be assembled in the form of a handbook for general distribution.

An indefinite number of kiln runs will be made under this project during the fiscal year 1920. A publication on the "Selection and Conditioning of Wood for Vehicles" will be completed. Work will be started on the effect of kiln drying to bone-dry condition and then allowing reabsorption on the strength and brittleness of wood, as compared with wood dried down to a given moisture content without reabsorption and effect of widely varying conditions during kiln drying on the rate of drying and condition of the wood as compared to drying under uniformly steady conditions.

168. Bending and drying bent furniture stock (L-234-1).

Cooperative study in bending and drying under commercial conditions has been conducted by Laboratory representative at a chair manufacturing plant. Characteristic problems involved have been ascertained and some of the principles involved in bending wood have been investigated.

Report of cooperative study is being prepared.

169. Study of microscopic structure of important woods with special reference to relation of structure to physical and mechanical properties (L-20). This work is carried on under several subheadings, the status and continuance of which are as outlined below. Plans for a study of the nature and properties of "compression wood" are outlined. An article on "Some Defects Found in Airplane Wood" is to be written.

(*a*) *Identification.*—Information has been collected on the identification of several genera of American woods. Over 17,000 specimens submitted by the Service and cooperators were identified in 1918. Special studies of various groups of woods have been made, as, for instance, the work on the identification of woods classified as mahogany; also the separation of Douglas fir and Sitka spruce. A working key covering about 125 species of foreign woods has been prepared. A number of articles and bulletins have been published.

Continuous identification of specimens submitted. Special studies to be made as time permits on the identification of pines, material of which has been collected, and also on oaks and hickories. Each study will furnish material for a publication. A revision for publication of the article on the identification of mahoganies is planned. Government bulletin "Identification of Furniture Woods" is to be prepared.

(*b*) *Fiber Measurement Studies.*—Specimens submitted intermittently. Recently some work has been done on cotton linters.

No work planned.

(*c*) *Resin Studies.*—Partly completed. Most of the material collected. No work has been done on this for about a year due to pressure of war work. Complete study on pines and if possible obtain comparative data from larch and Douglas fir. The results will be presented in form for publication in Journal of Agricultural Research or other Government bulletin.

170. Penetrance of wood by preservatives (L-22). Work as outlined to date completed. Article on "Bordered Pits in Douglas Fir" submitted for publication in Journal of Forestry.

Some miscellaneous work will probably be done on the microscopic studies of glue joints in cooperation with the section of preservation.

171. Mold studies. Effect of molds on woods used for airplane and vehicle stocks (L-245). Investigation partially complete. Material collected and cultures prepared.

Study of material on hand and preparation of illustrated report for publication in Journal of Agricultural Research or Phytopathology.

WOOD PRESERVATION

172. Physical and chemical properties of coal tar creosote. Volatility (L-144-1). Work on this project has been under way for a number of years and results have been covered by a series of articles and Government publications. A further publication on "Coal-Tar and Water-Gas Creosotes" is practically completed.

(*a*) Preliminary calculations indicate that the loss of creosote from treated wood can be expressed in the form of a mathematical equation. The equation must contain some function of the volatility of the creosote, the amount of oil used, and the time and temperature at which the treated wood is held. The data available can not be used because the pieces of wood contained an unknown amount of water. Working plan written.

Sections of wood to be treated and held at various moisture contents and temperatures.

(*b*) Tests are under way to determine the composition of creosote remaining in telephone poles after 22 years of service. Work of drawing conclusions to be continued especially in regard to volatilization of the creosote during service. The manuscript on "Coal Tar and Water Gas Creosotes" will be reviewed and published during the year.

173. Efficiency of various fractions of coal tar creosote and other preservatives in protecting southern yellow pine from marine wood borers (L-120). Work on this project has been under way for a number of years and preservatives have been studied that give great promise of improvement in protection from marine borers. Articles covering results have been published.

Recent work in cooperation with the Bureau of Fisheries promises to result in the development of a greatly improved marine preservative.

Prepare plans for work along the lines indicated by results and conduct such work as opportunity affords. Inspect specimens located in Pensacola and Gulfport.

174. Swelling and shrinking of wood as influenced by various treatments and coatings (L-134-5).

Information has been obtained upon the effectiveness of various kinds of varnish and other coatings, and various numbers of coats of the same varnish. Improved methods of finishing with varnishes have been developed. A very effective method of preventing moisture changes by the application of aluminum leaf and varnish was developed and demonstrated to the Air Service of the Army, and to the Bureau of Construction and Repair of the Navy Department. The results of this work have been published in a number of journals. A test on the durability of varnish and enamel coatings exposed to the weather is well under way.

The work is in cooperation with the War and Navy Departments. Durability studies are to be continued and results reported. Search for water-resistant coatings to be continued, especially such as would be suitable for the protection of glue joints in exposed wood work. Study of Forest Service paint problems to be continued.

175. **Inflammability of untreated wood and wood treated with fireproofing compounds (L-179).** Studies have been made upon the relative inflammability of various species of wood. Many methods of fireproofing wood by means of paints, coatings, and impregnations were studied and results have been published. A method of fireproofing shingles and a very effective fire retardent paint have been studied and are under development.

During the year 1917 plans had been made, but no work done, toward a series of tests designed to show the effectiveness of various details of construction in retarding fire.

The fireproofing of plywood for aircraft is to be studied, giving particular attention to the effect of fireproofing materials upon strength and water-resistance of glues and upon wood finishes. Further developments of fire-resisting problems as finances permit, with special stress on fire stops and to improve methods of testing fire-resistance of wood.

176. **Investigations of conditions in buildings which promote decay of timbers used in their construction (L-191).** A general field study has been made of conditions existing in wooden factory buildings with reference to decay and the development of methods of prevention. Articles covering results have been published.

Roof timbers were treated with sodium fluoride and with creosote in cooperation with the Southern Pine Association to be placed in the roofs of several textile mills in New York and New England. A working plan has been prepared covering the study of moisture conditions existing in buildings, but the study has not yet started.

The installation of treated timbers to be completed. Use of treated wood in buildings where decay is a serious difficulty, as in cotton mill and bleachery mill roofs, to be developed.

177. **Use of National Forest timber for ties (L-194).**

Manuscript prepared for publication.

Manuscript to be brought up to date and published.

178. **Experiments with railway crossties, in cooperation with the C. M. & St. P. Railway and the Bureau of Standards (L- 213).**

The test tract now contains about 630 ties treated with five different preservatives, and about 200 untreated ties. Four hundred additional ties have been treated and are now being installed. Measurements of electrical resistance of the ties are being made at intervals.

Two hundred additional ties to be treated in the spring of 1920 with a preservative to be decided later. Electrical measurements to be continued.

179. **Durability of treated and untreated wood (L-214).**

About 17 test tracks, 10 pole lines, 14 fence post tests, 6 mine timber tests, 4 piling tests, 2 wood block pavements, in cooperation with various companies, organizations, and individuals are under observation, and records are being collected from all other available sources. Records of service tests of ties, poles, and posts were published in the Proceedings of the A. W. P. A. and the A. R. E. A. in 1917 and later records of ties in A. R. E. A. Bulletin No. 210, Oct., 1918. Numerous other articles have also been published.

Inspections to be continued as conditions require, and collections of data from other sources to be continued. Cooperation with American Wood Preservers' Association and American Railway Engineering Association to be made use of in publishing data obtained on ties and other timbers. Publication on results of fence post investigations to be prepared.

180. The preservative treatment of poles (L-249). Work was begun about 17 years ago. Methods of treating telephone poles and fence posts were developed which have been generally adopted. A number of reports covering the work have been published.

No work has been done recently, but there is a growing demand for better methods of treatment for poles. A committee of the American Wood Preservers' Association desires cooperation in solving some of the problems now encountered by pole treating companies and users of treated poles, and work of this character may have considerable influence regarding the sale of National Forest species for poles.

Cooperation with the above committee and possibly with the District Forester in District 1 to be developed. Condition of poles known as case-hardening to be studied. Practicability of puncturing poles for non-pressure treatment, and feasibility of pressure treatment to be considered.

181. Laboratory tests on the comparative efficiency of various wood preservatives (L-117). Investigations have been under way for a good many years, the results of which have been covered by a series of articles and Government publications.

A set of specimens for tests on the effect of zinc chloride upon the strength of wood was treated 5 years ago, to be tested in November, 1919. Strength tests on zinc chloride specimens to be made and report prepared.

Efficiency of highly toxic substances dissolved in non-toxic oils. Preliminary work started. Working plan under way. A non-toxic oil to be obtained, if possible, from coal tar creosote, and the various materials usually found in coal tar creosote to be tested for any relationship between their toxicity in oil solutions and the solubility partition in oil and water.

The laboratory study is started on the study of the action of enzymes of timber-destroying fungi on wood. No active laboratory work for the present. Laboratory study to be continued as time permits.

Study of the fire retarding of shingles. Some preliminary work has been done with barium hydroxide as a fire retardent. Also on the standardization of methods of testing. If possible a standard method of testing will be worked out.

182. Experiments on mechanical operative features of pressure wood preserving plants (L-119). An extensive series of tests was conducted on this project a number of years ago, the results of which were published in a Government bulletin.

A detailed study of the treatment of Douglas fir, especially by the Boulton process was being pushed in cooperation with the West Coast Lumbermen's Association when interrupted by the war. No work done during the war.

It is planned to complete and report upon the Douglas fir studies already started, and on the basis of the information thus obtained plan additional work on the treatment of Douglas fir.

LAMINATED CONSTRUCTION

183. Study of glues and gluing (L-157).

Much information has been collected on the principles involved in the preparation of water-resistant glues and the properties of glue ingredients, and a number of excellent formulas for water-resistant glues have been developed. A great amount of information relative to the inspection and use of both water-resistant and animal glues has been obtained and made available to the War Department and the Navy Department. Many thousand tests have been made upon samples of plywood and glue submitted by Government officers and inspectors. Specifications have been prepared for hide glue for propellers, casein for casein glue, waterproof casein glue, and for water-proof plywood, grades A and B. A report dealing with glue in aircraft construction has been published by the National Advisory Committee for Aeronautics, Report No. 66. Much of the work is in cooperation with the War and Navy Departments.

Efforts to develop new glues of greater water resistance and other desirable properties to be continued. Manufacturers' gluing problems to be studied with a view to improving commercial practice and developing the technique of using all glues, but particularly water-resistant glues. Additional information to be obtained on principles involved in gluing, such as the manner in which glue takes hold of different species of wood, regulation of pressure, time, and other factors entering into the production of a glue joint. Properties and uses of marine glue to be studied. Additional study of properties of glue, such as shock resistance, strength, weather resistance, effect on tools, etc., to be made. Gluing of various species of native and Brazilian woods and other woods used in furniture and aircraft construction to be studied. Publication to be prepared from time to time as warranted by results.

184. Study of conditions affecting the manufacture of plywood (L-225-7).

Information has been obtained upon effect of moisture content of veneer upon the finished panel, and studies have been made on effect of amount of pressure upon strength and water resistance of the glue joint. Inspections have been made at many plywood plants and suggestions for improving methods made wherever possible.

Detailed study to be made of all the operations entering into plywood manufacture, with a view to improving commercial practice. This will include a study of gluing of cross grain and fancy veneers and a study of methods of preventing staining of face veneer. Publication on veneer and plywood to be prepared.

185. The influence of shrinkage and swelling stresses caused by atmospheric conditions upon the tensile strength across grain in laminated construction (L-227).

The following species have been manufactured and more or less completely tested: Central American mahogany, African mahogany, red oak, white oak, birch, gum, maple.

Observations, weights, strength tests, etc., in accordance with the approved plan have been made and recorded for permanent record. Preliminary reports covering three of the above species have been prepared: others are under way. The work is in cooperation with the Bureau of Steam Engineering of the Navy.

A complete series of tests will be made for Philippine mahogany and yellow poplar; other species will be added if deemed advisable. Reports will be prepared covering the various steps in conditioning for each species. These reports will then be combined into a species report. A final report covering all species will then be prepared.

186. Influence of atmospheric and manufacturing conditions on airplane propellers (L-233).

The following propellers have been manufactured: 33 from each of seven species; 6 of quartered red oak finished with aluminum leaf coating; and 3 of quarter-inch poplar stock with casein glue. Ten fins of true mahogany and 8 of red gum have been manufactured. All of these have been placed in the conditioning rooms for test. Observations, weights, measurements, etc., in accordance with the approved plan have been made and these have been recorded and plotted for permanent record. Several reports based on information obtained to date have been prepared for publication. Work conducted in cooperation with the Bureau of Steam Engineering of the Navy.

Thirty-three propellers each of yellow poplar and Philippine mahogany are to be manufactured. The work on fins is to be continued until 24 from each of the 9 species have been completed. Reports will be prepared from time to time as data warrants and a final report covering the entire investigation will be prepared when the schedule has been completed.

187. Suitability of laminated construction for various commercial products (L-247).

Laminated shoe lasts have been constructed and tested with very satisfactory results. There appears to be a very good chance of these being put into commercial production. Laminated bowling pins manufactured and tested have given excellent service and are in every way equal to solid pins. Laminated wagon axles, bolsters, hubs, and poles have been made up and tested by placing them out in the weather. Two wagons using laminated stock made up at the Laboratory are now being built for service tests. Laminated poplar hat blocks manufactured at the Laboratory and tried out in service at a local hat blocking establishment are showing satisfactory service. Other articles under investigation are athletic goods, such as Indian clubs and dumbbells, tool handles, and automobile sills. Reports have been prepared on shoe lasts and bowling pins.

It is planned to continue this work on laminated construction, taking up various articles as time warrants. In each case it is the intention to make a thorough preliminary trial of the article, prepare a report on the results, and then if satisfactory try to get commercial production started.

PULP AND PAPER

188. Comparative pulp making tests on various forest woods (L-168). Tests have been run on a large number of species by the soda, sulphate, and sulphite processes. The plans for future work contemplate complete pulping, bleaching, and strength tests by all three of the methods on all American woods such as might be suitable for pulp and paper manufacture. For each process the status and plans are as follows:

(*a*) *Soda Process.*—About 15 species of wood have been pulped by this process using modifications developed at the Laboratory. Four more species are available at the present time. Practically all woods suitable for reduction by this process have been investigated. Such additional woods as may be procured by the Laboratory will be studied.

(*b*) *Sulphate Process.*—Approximately 25 species have been treated using the sulphate process. Work is completed on the proper beating of sulphate pulp. A report has been prepared and submitted to the Nekoosa-Edwards Paper Company, who cooperated with us on this work. Practically all woods suitable for reduction by this process have been investigated. Such additional woods as may be procured by the Laboratory will be studied.

(*c*) *Sulphite Process.*—About 35 species have been pulped by this method. Additional work is outlined on about 14 species. Such additional woods as might be pulped by this process will be studied. Most of the more suitable woods have been pulped. The following are to be pulped: bald cypress, western hemlock, chestnut, sycamore, sugar maple, white oak, Port Orford cedar, Alpine fir, cucumber tree, western larch, basswood, black gum, birch, and jack pine.

(*d*) *Groundwood Process.*—The species of American woods suitable for pulp making under the groundwood process have been tested and the results incorporated in a comprehensive Government bulletin.

(*e*) In connection with tests to determine the suitability of American species for pulp making under the various processes, the processes themselves have been studied intensively with a view to improvements. Improvements of the sulphate and soda processes have been worked out and demonstrated on a commercial scale. Efficient methods for making ground wood pulp which reduced manufacturing waste have also been demonstrated. A series of articles and Government reports have been published. Work will be continued along the same general lines as in the past.

189. Development of methods and specifications for the purchase of pulp wood (L-216).

Considerable data have been gathered to show the relation between cord measure and measurement by weight in the purchase of pulp wood. Observations on the relative merits of the two systems have been published.

Work will be continued as opportunity offers.

190. Utilization of waste bark for tanning purposes (L-238).

The value of waste hemlock bark from pulp mills as a source for tannin for the leather industry has been determined. A report has been prepared and published in various technical journals covering the results obtained by this semi-commercial experimental work.

Make additional mill trials in cooperation with pulp mills and tanneries to collect accurate cost data and other essential information.

191. Study of the suitability of second-cut cotton linters and hull fiber for pulp and paper (L-253).

Experimental laboratory work completed. Reports published in a number of journals.

This work is carried on in cooperation with the Ordnance Salvage Board of the War Department.

Two mill demonstrations will be made where cotton fiber will be pulped on a commercial scale to determine yield, chemical and bleach consumption in order to properly evaluate this stock in comparison with other paper stocks.

192. Study of wood pulp, fiber and paper specialties (L-205).

(*a*) Methods of manufacturing roofing felt from spent hemlock bark have been developed which are now in commercial use.

(*b*) Work has been completed on fiber containers, shrapnel shell plugs, template paper, boxboard, waterproofing boxes, baling and packing papers, and waterproof labels. Further work will be done as occasion demands.

(*c*) Laboratory work completed on desaturating waste roofing and shingle stock to recover the asphalt and paper stock. The cooperators believe that felt as made from desaturated stock is entirely satisfactory. Report will be prepared for publication.

(*d*) Laboratory work practically completed on suitability of primary fiber containers for food products and other commodities as substitutes for metal containers. Two reports now being prepared. Collection of commercial paper containers and special containers, as developed at the Laboratory for testing purposes will be submitted to the Bureau of Chemistry.

(*e*) Routine testing work is done on miscellaneous papers submitted by cooperators. Papers will be tested as they are submitted.

DERIVED PRODUCTS

193. Destructive distillation of hardwoods (L-152-1).

Formerly only beech, birch, and maple were considered suitable for distillation. Tests have been made which show that oak, hickory, ash, and some other hardwoods are also suitable. A series of articles and a Government report have been published. Two species, mesquite and post oak, recently studied to determine suitable location of War Department distillation plants.

No species studies are contemplated except those which may arise from outside sources.

194. Methods of increasing the yields of valuable products in the destructive distillation of hardwoods (L-152-2).

New methods have been developed for the distillation of hardwoods by which it has been possible to increase yields of various products considerably. Results have been published as articles.

This was discontinued during the war but the work on catalyzers has been started again. The study of the effect of catalyzers on the yields of alcohol and acid has been combined with a study of the value of the charcoal as a decolorizer. New methods for distilling the wood-catalyzer mixture have been devised so as to obtain a solid charcoal.

Work along these lines will be continued.

195. Studies of methods for refining hardwood distillates (L-152-3).

A start has been made in the utilization of hardwood tars for other purposes than fuel; for example, as flotation oils. Cooperation with Salt Lake Station of Bureau of Mines on "Flotation Oils from Hardwood Tars" finished and published. Further cooperative work of a more fundamental and detailed character has been arranged with the Seattle Station of the Bureau of Mines.

Continuation of cooperative work with Bureau of Mines.

196. Study of methods and processes used in securing turpentine and rosin by extraction from woods with chemicals (L-159).

This study has been under way for several years and some improvement has been made in extraction processes which have been adopted in commercial practice. Work on this project was discontinued during the war and has not been resumed. It has been found difficult to apply the experimental results in commercial practice.

New problems have lately developed in commercial practice and promising methods for solving them have been thought out so that some work along this line will be started if possible.

197. Study of products obtained from conifers by distillation (L-158).

A detailed study has been made of the composition, properties, and industrial values of wood turpentines and methods developed for their proper refining. Results have been incorporated in a Government bulletin. This work was dropped during the war in order to concentrate on National defense problems.

If the cooperative work with the Bureau of Mines on hardwood tar flotation oils is satisfactory, it is planned to carry out similar work with the pine tars, but it will be some time before this work can be started.

198. Turpentine experiments (L-149).

(*a*) Several series of experiments have been conducted to determine the feasibility of turpentining western conifers. A Government report has been published.

(*b*) Work on production of Venice turpentine from western larch has been started and one year's crop of products has been gathered and tested. Continuation of tapping experiments is planned.

(*c*) War emergency work on production of toluene and isoprene from turpentine finished. No more experimental work along this line is planned, but a report will be prepared for publication.

199. Tests of different methods of turpentining (L-190).

(*a*) As a result of studies undertaken during the last 25 years two radical changes in methods have been developed: first, involving the substitution of the cup and gutter for the box method; second, the introduction of shallow chipping. Numerous articles and bulletins have been published.

(*b*) Comparative tests of the French, American, and a modified American method are now under way.

(*c*) Two years' work in the comparison of three different methods of turpentining on a commercial scale is finished, but the results are indefinite. No further work is planned, but it would be desirable to do more if proper cooperation could be obtained.

200. Production of ethyl alcohol from wood (L-150).

Investigations under way for a number of years have resulted in various improvements in the process of making ethyl alcohol from wood, especially in the conditions of cooking and in the method of fermentation. The report covering the first portion of this work, both on species and on methods, has been written. Additional species have recently been studied. As war emergency work, cotton seed hulls and bagasse were studied and the laboratory work on these materials is practically finished.

The plans for further work include:

(*a*) Study of effect of catalyzers; (*b*) production of organic acids from wood sugars; (*c*) identification of the various wood sugars; (*d*) study of less costly fermentation procedures; (*e*) write up for publication the work on cotton seed hulls and bagasse. No further work planned on these materials.

201. Study of value of hydrolyzed sawdust as a stock food (L-A 150).

Work has been started in cooperation with the University of Wisconsin in which practical feeding tests are made.

Continuation along this line.

202. Ethyl alcohol from waste sulphite liquor (L-241).

One stage of work finished, report written and published in "Paper."

Cooperation with Section of Pulp and Paper on effect of: (*a*) sulphur acid; (*b*) different acid compositions, and (*c*) other catalyzers on sugar production.

203. An investigation of the chemical and physical properties of California eucalyptus oil (L-B 166).

Material obtained and work started.

Continue with special attempt to produce an oil which will conform with U. S. Pharmacopœia requirements.

204. The chemical composition of American woods (L-112).

A study of the chemical composition of American woods has been under way for a number of years. Seven or eight important species have been studied and a part of the results published as an article.

(*a*) Work on the comparison of species was stopped during the war but has been recently resumed. It will be continued according to the original working plan together with the necessary modification of methods which may develop from increased information on the subject.

(*b*) Work on the fusion of wood with alkali for the production of acetic acid is finished and the report published. This was emergency war work and nothing further along this line is planned.

205. Bleaching and equalizing color of heartwood and sapwood of various species (L-250).

Some work has been done on oak chair stock and a method has been developed on a small laboratory scale which gives satisfactory results.

Make commercial demonstrations in cooperation with some furniture factory and work on other species if possible.

206. The production and quality of American storax from Liquidambar styraciflua (sweet gum) (L-251).

Preliminary study and report finished. Cooperative study of production methods started.

Continue along this line with introduction of native products to consumers.

PATHOLOGY

207. Toxicity of preservatives with pure culture in petri dishes and jars (L-137).

Tests have been completed on various coal-tar creosotes and fractions, on water-gas-tar creosote, and mixtures of these with various fractions, spirittine, S. P. F. carbolineum, Morel preservative, B. M. mixture, zinc sulphate, cresol mixtures, beechwood tar distillates, preservol Mykantin, anthrasota, Barrett's grade 1 oil, and reports prepared. A number of articles published and also a Government bulletin.

Tests will be carried out on various preservatives referred during the year.

Assigned to Forest Products Laboratory, in cooperation with the Bureau of Plant Industry.

208. Relative resistance of untreated woods to decay (L-170).

These tests were initiated about ten years ago, and include several series of representative American woods. The tests fall under three subjects:

(*a*) By pure culture of fungi in jars (L-170*a*).

Regular inspections are continued as often as necessary.

Regular tests will be continued using different fungi and adding new woods as they become available.

(*b*) By fungous pit tests (L-170*b*).

Regular inspections are continued as often as necessary.

Tests will be conducted with new woods as they become available.

(*c*) The effect on the chemical composition of wood of the attack of fungi (L-170*c*). Preliminary work was completed and the report written. Continue the chemical study of the substances contained in wood which render it resistant or immune to fungi, in cooperation with the Section of Derived Products.

Assigned to Forest Products Laboratory, in cooperation with the Bureau of Plant Industry.

209. Determination of the minimum and maximum moisture content of wood which permits the growth of fungi (L-171).

Some preliminary work has been done and apparatus constructed.

Study to be completed as time permits.

Assigned to Forest Products Laboratory, in cooperation with the Bureau of Plant Industry.

210. Thermal and humidity death point study of a wood rotting fungus (L-212).

Some preliminary work conducted to determine in connection with project L-191 the temperatures and humidities that will kill various wood rotting fungi.

The relation of moisture to fungous growth will be further investigated on an extensive scale and temperature tests will be continued on various wood-destroying fungi to supplement earlier tests.

Assigned to Forest Products Laboratory in cooperation with the Bureau of Plant Industry.

INDUSTRIAL INVESTIGATIONS

211. Vehicle study (L-222).

(*a*) Data on methods and equipment for drying vehicle stock have been given to many of the vehicle manufacturers and resulted in an improvement in the results formerly obtained. Further work will be taken up as the occasion demands.

(*b*) The field work has been completed and preliminary work started to determine the thermal point of various wood-rotting fungi under dry and humid conditions in vehicle stock.

Toxicity tests will be continued, a few more steaming and drying experiments made, and report completed.

(*c*) Various methods of bending vehicle stock have been tried.

Bending work will be continued as time and funds permit.

212. A study of the use of wood in railway cars (L-237).

(*a*) Some cooperation has been carried on with the committee on the purchase of treatable timber of the American Wood Preservers' Association, although no work is now in progress.

No definite work planned. The work will be carried on whenever advisable.

(*b*) Several field trips have been made to various car factories in order to study their kiln drying problems.

No definite work planned. The work will be carried on whenever advisable.

(*c*) A study has been made to determine the advisability of using more wood in railway cars.

No definite work planned. The work will be carried on whenever advisable.

213. Shipbuilding (L-224).

(*a*) A handbook on the use of wood in shipbuilding has been prepared and sent out to various people for review and criticism before publication.

(*b*) Experimental deck has been caulked with various pitches and the necessary inspections made every week. The laboratory tests on the original pitches have been practically completed.

Continuation of inspections and interpretation of data are planned.

(*c*) The use of various species of woods for ships has been studied.

Work will be carried on as the occasion demands.

214. Wood waste exchange.

Lists of plants that have waste for sale and lists of plants that can use comparatively small pieces have been maintained for a number of years and have been the means of bringing together a great many buyers and sellers of wood waste.

The exchange will be maintained as in the past. Quarterly lists of buyers and sellers will be compiled.

Assigned to the Washington office of Forest Products.

215. Utilization of commercial woods by species. To bring together in convenient form the available information on the supply, demand, and properties of the different commercial woods and to show their relative values for various purposes. Results to be published in bulletin form.

The following reports have been issued: F. S. Bulletin No. 99, "Uses of the Pines," Dept. Bulletin No. 12, "Uses of the Beeches, Birches, and Maples," Dept. Bulletin No. 523, "Utilization of Ash," Dept. Bulletin No. 683, "Utilization of Elm." A bulletin on the "Utilization of Black Walnut" is practically completed. Considerable work has been done on a report covering the utilization of the oaks.

During the year it is planned to complete the preparation of bulletins on walnut, the oaks, sycamore, and to get under way a bulletin on the hickories.

Assigned to the Washington office of Forest Products.

216. Lumber grading study (L-252).

(*a*) Considerable work was done before the war on the development of a universal grading rule applicable to all species and all regions. This work has been taken up again in cooperation with the National Lumber Manufacturers' Association after being discontinued during the war. Cooperation in developing a universal rule will also be arranged with consumers of various classes of lumber and with lumber dealers.

(*b*) A report is in preparation on the grading of lumber by manufacturers' associations.

Assigned to Forest Products Laboratory and Washington office of Forest Products.

217. Lumbering methods and costs (L-4, District 1–8). To secure data on methods and costs of logging and lumbering manufacture as a basis for stumpage appraisals. To secure data as a basis for the development of logging engineering. To conduct efficiency studies in logging and milling operations. Where possible these studies to be considered with reference to the practice of forestry.

Begun in 1912, and continued in all of the Districts until the beginning of the war. The following reports have been published: Dept. Bulletin 440, "Lumbering in the Sugar and Yellow Pine Region of California," Dept. Bulletin 711, "Logging in the Douglas Fir Region," Dept. Bulletin 718, "Small Sawmills and their Equipment, Construction, and Operation." "Report on Lumber Manufacture in the Douglas Fir Region," now ready for printing.

To be renewed during the year if personnel permits.

Assigned to all Districts.

218. Mill scale studies (L-1, District 1–8). To determine the mill overrun and the percentage of different grades of lumber obtained from various grades of logs of all important commercial species; to determine the relative quantity and quality of lumber manufactured from timber cut by National Forest methods and under methods prevailing on private lands; to show the effect of cutting regulations upon the yield of lumber and the amount and quality; to determine the practicability of using uniform log grades for particular species in timber reconnaissance, and also in timber appraisals.

Studies completed in District 1 for larch, western white pine, lodgepole pine, western red cedar, Engelmann spruce, western hemlock, and Douglas fir; in Districts 2 and 3 for western yellow pine; in District 5 for sugar pine, western yellow pine, Douglas fir, white fir, and incense cedar; in District 6 for Douglas fir and western yellow pine; in the East for tapped and untapped longleaf pine, maple, small yellow pine mills, red and white oak. In District 7 work has been done on northern hardwoods and on southern yellow pine in Arkansas. For a number of the above species several studies have been made to cover timber of different quality and of different types of mills. A number of reports have been published in trade journals. Work was suspended during the war.

In District 6 an analysis will be made of the results of Douglas fir studies and possibly a further study undertaken during the year. A study of western hemlock will be made if a satisfactory mill can be found. At the Forest Products Laboratory the preparation of a general publication embodying the results of all the mill scale studies so far conducted will be begun. It is doubtful if other District studies can be initiated during the year.

Assigned to all Districts and Forest Products Laboratory.

219. **Lumber depreciation study (L-3, Districts 1-8).** To determine the depreciation of lumber in volume and quality from the time of sawing until that of shipment or sale, including depreciation in open-air seasoning, kiln drying, handling, storage, and machining, as a basis for more efficient operations and for National Forest appraisals.

Work under way several years. In District 1 studies conducted on western yellow pine, western white pine, and western larch. In District 5 on sugar pine, western yellow pine, Jeffrey pine, Douglas fir, white fir, and incense cedar. In District 6 on western yellow pine and Douglas fir. In the East on red oak, white oak, and southern yellow pine. For several of these species studies have been made covering different climatic conditions, etc. The work was suspended during the war.

In District 6 a further study of Douglas fir may be made if cooperation can be arranged. This may include also western hemlock. The results so far secured from all depreciation studies will be analyzed to determine whether sufficient data is available to justify a report covering all results for the entire country to date. It is doubtful if other field studies can be initiated in the Districts during the year.

Assigned to all Districts and Forest Products Laboratory.

GRAZING INVESTIGATIONS

ARTIFICIAL RESEEDING

220. **Artificial reseeding of depleted range lands.** Manti.

In 1910 areas were seeded at an elevation of 10,000 feet by officers of the Manti Forest. In 1912 two areas were seeded to Kentucky bluegrass, timothy, orchard grass, and Hungarian brome. The seed on one area was trampled in by sheep, and on the other area it was harrowed in. Thirty-two quadrats have been established to determine rapidity of establishments of vegetation, loss due to drought, and vegetative increment. In 1914 three additional areas, between 9,600 and 10,000 feet elevation were seeded to Kentucky bluegrass, timothy, and brome grass. In 1915 seasonal seeding tests were begun, plantings were made in spring, summer, and fall with Kentucky bluegrass and timothy. In 1917 six plots were seeded in strips to determine the practicability of revegetation by this method with the idea that seed from the seeded strips will be distributed and result in revegetation of adjoining areas. In 1918 a large plot was established on a long-used bedground, part of which was plowed and a part untreated and subsequently seeded to violet wheat-grass (*Agropyron violaceum*) and mountain brome-grass (*Bromus marginatus*). Observations to date indicate that the cultivated species are able to compete fairly successfully with native species where the site is favorable to the growth of cultivated species. Kentucky blue-grass appears to be gaining ground after several years, although it was less promising than other species at first.

It is important to determine the longevity of various species worked with and to do this will necessitate continued observations for a number of years. One of the most important things to be worked out in the practical application of arificial reseeding is the proper selection of the lands. It is the plan to attempt to correlate lands suitable for artificial reseeding with the character of the native vegetation which they support. If this can be done the ill effects of such factors as excessive soil packing, for instance, which does not directly affect soil fertility, may be recognized. Date of completion, probably 1922.

Assigned to A. W. Sampson.

221. Testing the suitability of certain new varieties of alfalfa for range reseeding. Great Basin Experiment Station.

Approximately 100 plants of alfalfa, varieties Nos. 336 and 532, were planted in the nursery in 1913. In 1914 fifteen specimens of each variety were planted at an elevation of 9600 feet. The plantings at this elevation gave negative results. At the Experiment Station vegetative growth has been fairly good, but seed has not matured. Sites were selected and fenced for a plantation in the oak brush type in 1917 and the plantings were made in the spring of 1918. Owing to the dryness of the soil most of the plants died.

The plantings at the Experiment Station and at the higher elevations have shown that the alfalfas have no commercial value above 8000 feet elevation in this region as they do not produce seed at these elevations nor do they reproduce vegetatively. Plantings at these elevations, therefore, have been discontinued.

Some of the plants remaining in the oak brush planting site came through the season in fairly vigorous condition. Their growth and general development will be observed next season. Date of completion, probably 1920.

Assigned to A. W. Sampson.

222. Cultivation of indigenous forage plants for artificial reseeding. Great Basin and Fort Valley Experiment Stations.

Thirteen species of native forage plants have been tried out to date in the nursery at the Great Basin Experiment Station. Of this lot one species, *Agropyron riparium*, has proved well adapted to the climate and soil of the region, and has made remarkable growth and extension through vegetative reproduction. The other species have been either failure or of little promise. In 1913 similar experiments were started at the Fort Valley Experiment Station with thirteen native grasses. Of these, four show promising results, six have produced a thin stand, and three have been failures.

At the Great Basin Experiment Station the investigation will be continued with additional species, care being taken to select those which show possibilities in the way of extension of range. Seed of the species now in the nursery will be used for seeding under range conditions outside of the nursery. Also seed of *Mertensia*, collected on the Uinta Forest in 1917, will be used for experimental seeding on range near the Experiment Station. Further, an experiment is planned for the Uinta Forest in seeding depleted areas with seed of valuable native forage plants collected on nearby range to test the feasibility of hastening the revegetation on denuded areas. At the Fort Valley Station observations will be continued until all species have produced seed. A report will then be written and the project will be closed or extended to range reseeding if the results warrant. Date of completion, indefinite at the Great Basin Experiment Station, probably 1919 at the Fort Valley Station.

Assigned to A. W. Sampson and G. A. Pearson.

223. Artificial reseeding of range in Southwest.

At the Jornada Range Reserve, two plots were seeded to slender grama and two to hairy grama in the spring of 1916. Two acres seeded to alfilaria in November, 1916. Additional seedings of alfilaria made in the winter of 1916 and 1917. All these seedings show negative results. During the spring of 1917 Russian thistle was seeded on part of the desert range. Thus far the results appear to be negative. The drought of 1917–18 was severe enough to kill out part of the native grama grass. Additional seeding tests were inadvisable during this period.

Climatic conditions are unfavorable to the success of introduced plants, but efforts will be continued to find some hardy species which will be successful and increase the forage crop. Such species as appear to have some promise will be tested. If possible hardy browse species will be selected later. Tests will be continued as species are available during the continuance of the investigations at the Jornada Reserve.

Assigned to C. L. Forsling.

224. Improvement of forage crop on certain burned-over lands in western Montana and northern Idaho of District 1 and in District 6.

Minor tests in seeding have been undertaken by local Forest officers, and favorable results appear to have been secured on the Okanogan Forest. The experiments have not been given the necessary attention, however, to justify conclusions. Seeding tests have been conducted beginning in 1917 in connection with the study of burned-over brush areas on the Crater National Forest, and the results are somewhat promising.

The experiments on the burned-over areas on the Crater National Forest will be continued and probably extended. The seeding done on the Okanogan Forest in the fall of 1917 will be continued under observation. A few additional tests will be started in District 6 and probably time will be devoted to examining areas where artificial reseeding may be warranted. Date of completion indefinite.

Assigned to D. C. Ingram.

NATURAL RESEEDING

225. Range improvement by natural reseeding. Great Basin Experiment Station.

Study initiated in 1912 on the "Two Mile Strip," Manti Forest. The quadrat and intensive plot methods of study employed to give records as to life history performances of the more important plant species. Observations made each season. Thirty-five quadrats and five protection plots 40 feet square established. One-half the quadrats chartered each year until 1917, when only a few of the important plots were chartered owing to lack of help. Complete root systems were obtained for about 60 species in 1917, and approximately 150 photographs showing complete root systems and successional phenomena were made. An additional 40 sketches of root systems were made in the field, and a large number both of detailed and extensive sketches showing character of vegetation and succession were made under different field conditions. The object of the study of root systems is to develop a clear understanding of the succession of various important species, and the application of this succession in range management. This work was continued in 1918.

The results obtained in the case of the plant indicator studies appear to be fundamental in character to the management of the range. The data have been published in U. S. Department of Agriculture Bulletin 791. Close cooperation with the local officers of the Manti Forest was arranged last year and the investigative officers at the Experiment Station working with the administrative officers inspected most of the badly overgrazed range on the Manti Forest during the past season.

Owing to the excessive number of stock it was not possible to apply to any appreciable extent the deferred grazing. The Station officers will do all they can in 1919, however, to assist the Supervisor in applying improved range management methods generally. This extension of the project will result in a clear demonstration as to the value of the principles worked out by the Experiment Station and will eliminate difficulties hitherto encountered in controlling grazing on the portion of the Two Mile Strip which is under experimental observation.

Owing to soil erosion, heavy packing, and other "earmarks" of range depletion revegetation is taking place very slowly. It is essential that the study and observations be continued until we have more definite information as to the time required for revegetation under various conditions of depletion of vegetation and soil. Consequently this project will be continued for a number of years.

Assigned to A. W. Sampson.

226. Rotation grazing, Medicine Bow.

Initiated in 1914. Compartment No. 1 grazed season along by cattle, and No. 2 only after seed maturity in 1914 and 1915. This order reversed in 1916 and 1917 and again reversed and grazed as originally in 1918.

Fenced compartments will be continued to be grazed alternately, and observations as to results will be continued. Thus far the results show satisfactory progress. Date of completion, not earlier than 1920.

Assigned to L. H. Douglas.

227. Natural revegetation, Southwest.

A practical system of deferred grazing has been in application on 11 of 13 pastures at the Jornada Range Reserve during the past four years. A comparative study has been made of results secured on the Reserve and results secured on adjoining Public Domain range where grazing is unregulated. Up to 1917, 88 quadrats were located and chartered, some two and some three times a year in connection with this study. Some additional quadrats have been established during 1917 and 1918. To supplement the quadrats a number of small fenced areas have been established and quadrats established in and adjacent to them. The results secured up until 1917 were published in U. S. Department of Agriculture Bulletin 588. During 1918 a progress report was written and the more important quadrats were chartered. The deterioration of the range, as a result of the continued drought, was carefully studied.

On the 50,000 acres under experimental management at the Santa Rita Range Reserve in Arizona, the number of stock grazing within the seven pastures was greatly reduced during the main growing season, July to October, and the range given a chance to reseed as a result of deferred grazing. This protection followed rather heavy grazing on most of the area for two years, and will give an excellent opportunity to observe improvement as a result of deferred grazing. Prior to 1918 80 quadrats and 15 small fenced areas had been established and charted several times to determine changes in vegetation. In addition several quadrats were established during 1918. Practically all the quadrats were chartered once and the more important twice. A progress report was written.

The quadrats already established will be recharted probably twice next year with few exceptions, and accurate record will be kept of the number and dates of animal days feed furnished in each pasture during the year. Careful observations for the areas as a whole will be made to supplement the detail data secured from the chartings. The studies will be extended and strengthened by the establisments of additional quadrats, small protected areas, and small pastures where definite control of the stock can be exercised. The recovery of the different types of vegetation from the detrimental effects of the drought will be carefully studied. Minor observations have already been started to determine more accurately the particular ways in which the forage plants reproduce at the two reserves. These indicate that reproduction vegetatively is perhaps more important than reproduction from seed. The drought has seriously interrupted these studies, but additional work will be undertaken along this line at the earliest opportunity as the method of reproduction may necessitate change in the proposed plans for grazing, which are at present based upon reproduction from seed rather than vegetative reproduction.

The great variation in vegetative growth due to variation in rainfall on these two reserves in different years, and the necessity for meeting the requirements of the stock have resulted in departures from any previously arranged intensity of grazing. These difficulties must be met in practical management and it is desirable, therefore, to meet them in the experimental management as they occur through a period of years. As a consequence this project will be continued as long as the reserves are under experimental management. Additional water development and additional fences will make it possible to intensify the study, and as time goes on the plan of grazing will be slightly varied between pastures of the same reserve in order to secure data on all possible phases of the problem.

Assigned to C. L. Forsling and R. R. Hill in cooperating with J. T. Jardine and W. R. Chapline.

228. Relation of frequency of grazing to vigor of vegetation. Great Basin Experiment Station.

Project initiated in 1916. Four plots each of native brome-grass (*Bromus marginatus*), Hungarian brome grass and violet wheat-grass (*Agropyron violaceum*), each plot containing 30 specimens, were planted in the nursery in the autumn of 1916. In 1917 and 1918 the herbage of these plots was cut according to the following plan:

Stage of growth when cut.	Native brome.	Hungarian brome.	Violet wheat-grass.	Time of cutting.
Cut after natural drying. Seed ripe and disseminated	Plot IV	Plot V	Plot XII	Oct. 8
Cut at maturity, leaving aftermath	Plot III	Plot VI	Plot XI	Aug. 27
Cut at maturity and aftermath removed	Plot II	Plot VII	Plot X	Aug. 27 Oct. 8
Cut four times during season	Plot I	Plot VIII	Plot IX	June 28 July 31 Aug. 27 Oct. 8

In each cutting, except where the plants had matured their seed and had dried up before harvesting, the green and dry weights were recorded. Complete root systems of five specimens, which were obtained from each plot at the end of the growing season, were prepared for chemical analyses with a view to determining the amount of starch and proteids stored in the tissues for the stimulation of next year's growth. The results to date have thrown much light on the proper season of grazing, longevity of plants according to frequency of grazing, and other phases pertinent to improved range management.

It is planned to establish more plots for detailed study of the character here reported, and it will be necessary to work with more specimens per plot. Accordingly seed of 11 species was collected and sown for transplanting next spring. About 100 specimens will be established in each detailed plot, the planting to be done in rows rather than in blocks. Larger plots no less than 125 of an acre will be established for the purpose of carrying out the same methods of herbage removal on a larger scale to check the results of the more careful work on the smaller plots as regards volume of herbage produced. The frequency and seasons of cutting will in all probability be continued as in the past. During each winter a chemical analysis will be made of the root and herbage samples obtained during the preceding summer. If initiated on the scale planned in 1919 the project should be completed by perhaps 1923.

Assigned to A. W. Sampson.

FORAGE PLANTS: DISTRIBUTION AND ECONOMIC IMPORTANCE ON NATIONAL FORESTS

229. Distribution, natural habits and economic importance of forage plants, Districts 1 to 8.

Nearly 38,000 specimens have been collected to date, representing about 4,800 species. During 1918 about 1700 specimens were submitted, identified, and notes in part furnished the collectors: 96 additional grasses have been reported since "Notes on Grasses" were printed; about 9500 plants have been mounted to date, properly labelled and filed in Washington, besides a great deal of similar work in District and Supervisors' offices; manuscript of economic notes for about 300 species were prepared during 1918; material for additional important genera were grouped and arranged for ready reference and a number of important genera check-identified in 1918; several new species were collected during the year, and extension of range established for a number of other species.

Will continue collections, paying special attention to observations.

on economic value. Continue compilation of economic notes and submit booklets of notes on range plants of the National Forests for publication as soon as they can be prepared.

Assigned to W. A. Dayton.

PROTECTION

230. Effect of grazing upon reproduction of western yellow pine.

Main study and supplementary study started in 1912. The main study completed in 1915 and report published as U. S. Department of Agriculture Bulletin 580 in December, 1917. No field work on project during 1917 except the general observations. During 1918 all plots on the Coconino Forest were reexamined and the stakes reestablished in cooperation with the Fort Valley Experiment Station.

It is planned to reexamine the plots, perhaps every two years, for the purpose of finding out the percentage of the reproduction originally on the plots when the study was started, which eventually develops beyond injury by grazing, and to determine to what extent the new reproduction becomes established. It is possible that the study will need to be continued to find out if the desired amount of reproduction will come in eventually if grazing is continued and if so what delay has been occasioned by grazing and the effect of this delay upon the final mature stand of timber, either in quantity or time required to produce it. Date of completion, probably 1924.

Assigned to M. W. Talbot, and G. A. Pearson.

231. Effect of grazing on aspen reproduction, Great Basin Experiment Station.

The experiment was initiated in 1912. In all 122 sample plots 10′ × 50′ have been established. In addition four clear cut plots $^1/_{10}$ of an acre each, two of which are fenced and two unfenced, have been under observation since 1913. The results show that the rate of height growth of the plants and the intensity of grazing are the determining factors in the management of cut-over aspen lands. Sheep will have to be excluded from clear-cut aspen lands for at least two years following cutting. Moderate grazing may then be allowed without seriously interfering with the stand of aspen desired. Cattle cause very little damage to reproduction if moderate grazing is resorted to. U. S. Department of Agriculture Bulletin 741 presents the results of the investigation, and suggestions for the management of grazing in the aspen type.

The transects on the clear-cut aspen plots in Ephraim Canyon will be reviewed annually for three or four years. The plots established in standing timber adjacent to these clear-cut areas will also be examined. Observations on these plots will be continued until the reproduction is beyond damage by cattle browsing. The main project is completed. Supplementary work will be completed in 1920.

Assigned to A. W. Sampson.

232. Effect of grazing on erosion and streamflow. Great Basin Experiment Station.

Two comparable areas on typical local range at 10,000 feet elevation have been selected, fenced, mapped, and provided with sediment basins including drainage gates and shutters, water gauge registers, etc., for the measure of sediment and streamflow. Meteorological stations established and observations made since 1913. Both erosion areas are grazed once annually by sheep. Records of all run-off and erosion secured in 1915, 1916, 1917 and 1918. U. S. Department of Agriculture Bulletin 675 entitled, "Range Preservation and Its Relation to Erosion Control on Western Grazing Lands," presenting the data and the conclusion of the study was published in June, 1918.

The experiment in general will be operated as in the past until a definite relationship can be established between the run-off and erosion on the two areas from a given storm. A special snow survey will be made on the areas in the spring of 1919. Date of completion, indefinite.

Assigned to A. W. Sampson.

233. **Planting to check erosion.** Great Basin Experiment Station.

Approximately 1300 cuttings of aspen, willows, mountain elder, wild gooseberry, currant, and two species of bunch-grass planted on two different sites during the seasons of 1913 and 1914. In 1916, 900 plants consisting of several species which had previously shown some promise were planted in contour terraces, and grass was seeded along the terraces in the fall of 1916. In 1917 approximately 350 specimens of wild gooseberry, sweet sage (*Artemisia*), and yellow brush (*Chrysothamnus*) were planted in June in contour terraces on a denuded and eroding southwest exposure at 10,000 feet elevation. Direct seeding of mountain elder and wild currant was attempted but with negative results. Seeding to cultivated and native grasses was carried out both on old terraces and on some of the new terraces. Mountain brome-grass (*Bromus marginatus seminudus*), mountain bunch-grass (*Festuca viridula*), porcupine-grass (*Stipa minor*), squirrel-tail grass (*Hordeum nodosum*), Nevada blue-grass (*Poa nevadensis*), and three native wheat-grasses were the species used. A number of additional contour terraces prepared in the fall of 1917 for planting in early spring of 1918. These new terraces are wider than the old terraces, as it was found the old ones were too narrow to hold the run-off.

Owing to the relatively heavy destruction of plants in the terraces through trampling by cattle and horses, measures were taken in 1918 to fence the planting site. The posts were set and the wire purchased and delivered for placement prior to the opening of the grazing season, 1919. No new terraces were made for the next spring planting as it is planned to replant terraces where the cover is not satisfactory. About 1500 plants will be set out in 1919. Date of completion, indefinite.

Assigned to A. W. Sampson.

234. **Effect of goat grazing upon range, timber cover, watershed, and development of improved methods of handling goats.**

Studies initiated on the Gila and Alamo Forests in 1915. Three goat ranges on the Gila and two on the Alamo under observation during the grazing seasons of 1915 and 1916. Twenty quadrats located and mapped; 105 tree reproduction plots established and examined; two bands of goats placed under a better herding system with several instead of one camp, and comparative study made of results under this system and under the old one-camp system; studies made to determine principal forage plants on goat ranges and species best suited to goat grazing; studies initiated to determine carrying capacity of goat ranges and adaptability of different classes of range to goat grazing; progress reports prepared in winter of 1916 and short article published. In

1917 and 1918 the studies on the Gila and Alamo were continued. In addition, during 1917, examinations were made and reports submitted covering prospective goat ranges on the Santa Fe, Carson, Crater, Siskiyou, Siuslaw, Klamath, Shasta, and Lassen National Forests. In 1918 prospective goat ranges on the Gila, Lincoln, and Coronado Forests were examined and reports submitted. Considerable interest was created among goat growers in possible future development of the goat industry on brush ranges at present unused. Papers were presented before the National Mohair Growers' Association, December 10–12, 1917, and December 5–7, 1918, and Arizona Goat Raisers' Association December 3–4, 1918. The results secured from 1915 to 1917, except the effect of goat grazing upon reproduction, were published in U. S. Department of Agriculture Bulletin 749.

If possible in two or three years the quadrats and reproduction plots on the Gila and Alamo Forests should be recharted and reexamined respectively. and allotments previously under observation should be examined to determine their condition and the effectiveness of the methods of management practiced. A report should be prepared on the effect of goat grazing upon reproduction. The information secured from the study should be disseminated among Forest officers with the idea of securing proper inspection and administration of goat ranges. The application of improved methods of management should be extended on Forests and public domain by furnishing information through associations, individuals, and by demonstrations. If possible demonstration experiments in the most approved management of goats on the range should be arranged with growers on Forest or public domain range in Arizona and New Mexico to show exact results of these methods on range and goats and their practical application. The proposed work as outlined is in the nature of a line of work rather than a project. Consequently the studies will continue until satisfactory methods of management are adopted generally on Forest ranges.

Assigned to W. R. Chapline.

235. Effect of removal of competing grasses by grazing, on the survival, height growth and increment of young coniferous trees. Halsey Experiment Station.

Working plan prepared, plots established, and first measurements made in 1916. Plots reexamined in 1917 and 1918.

It is planned to graze the experimental areas heavier than in the past if this proves practicable, and to continue observations. If heavier grazing is not found to be practicable, observations will be discontinued as the present intensity of grazing does not produce sufficient effect to warrant conclusions. The project may be closed or extended when the report of results is received in the next few months. Date of completion, probably 1922.

Assigned to Halsey Experiment Station and L. H. Douglas.

236. Effect of fire on forage, California.

Project initiated on California Forest in 1915. One area burned on a sheep allotment in the fall of 1915, and plots established to study plant succession and reproduction of brush following burning. Plots examined in 1915, 1916, 1917, and 1918. The observations show that a great deal of herbaceous vegetation came in the year following burning and has been decreasing in amount since. During the first year following burning the brush reproduced rapidly and is gradually shading out the herbaceous vegetation. The first two years after burning the brush sprouts were fairly succulent and furnished a good deal of sheep feed. In the third year, however, the brush was becoming woody and very little of it was eaten by sheep. This fact and the gradual elimination of herbaceous species will probably result in the burned area being used but little if at all for grazing after the third year. Progress reports were submitted in 1917 and 1918.

In 1919 a grazing reconnaissance of 20,000 acres involved in this study will be made, the plots will be recharted in the spring and if necessary in the fall of 1919. Sufficient data will perhaps then be available to justify conclusions as to the advantage to grazing from burning brush areas similar to the one under study, the grazing carrying capacity of the burned area during each year for the three years following burning and the period during which the burned area is of value for grazing following burning. The sample plots will be continued for a number of years and will be reexamined probably each year to obtain additional data on vegetative growth as long as there is a change apparent. Date of completion, indefinite.

Assigned to F. D. Douthitt.

METHODS OF HANDLING STOCK

237. Small coyote-proof lambing enclosures in connection with lambing allotments.

Field work since 1910 on Cochetopa Forest. In 1914, 1915, and 1916 on Datil Forest. Report 1910 in Bulletin 97. Reports by local Forest officers 1911 to 1916. Three other articles published in National Wool Grower. The number of lambs saved has consistently been greater in the experimental band than in four to five check bands. Several sheepmen on the Cochetopa are installing similar improvements on their lambing ranges. Two large sheep producers on the Datil Forest have adopted the improved method, and improvements based upon the experiments have been adopted by many sheepmen.

In District 3 the project will be extended to include observations on lambing methods and results throughout the District for comparison with the results under the improved system. On the Cochetopa the experimental sheds and enclosures will be used by permittees who will report progress and success. General observations on lambing methods should be continued and reported with a statement of improvements along this line. U. S. Forest Service Bulletin 97 will be revised within a year or two, perhaps in 1919 if there is opportunity for field observations by the author during 1919. General observations should be continuous as this is an important line of work rather than a specific investigation, and there is much room for stimulating improved methods for Western States.

Assigned to J. T. Jardine.

238. Improved methods of handling sheep on Forest range.

Observations on Lewis and Clark, Madison, and Lassen Forests in 1912; study by Grazing Examiner on the Madison Forest in 1913 and 1914; study by a special man on Payette 1912, 1913, and 1914; study by Grazing Examiner on Bighorn in 1913 and 1914. Observations and good results on Madison, Helena, Lewis and Clark 1915–1917. On Ochoco, Wallowa, Whitman, Rainier, Malheur, Wenatchee, Umatilla, California, Lassen, Fillmore, Fishlake, Manti, and Sevier Forests new method put into effect, one or two bands carefully studied. During 1917 aggressive effort made to secure adoption of the bedding-out system on all Forests, and remarkable progress was made. General observations continued to determine difficulties and ways of overcoming them. Four short articles published in National Wool Grower and a chapter in U. S. Department of Agriculture Bulletin 790 on Range Management. Results now being compiled with the expectation of preparing a manuscript for publication.

The bedding-out system of handling sheep has passed the experimental stage. Approximately 60 per cent of all sheep on the National Forests are now handled according to methods approaching this system as advocated by the Forest Service. Continuous effort will be made to secure the adoption of this method by the remaining 40 per cent of sheep owners, and to perfect a system of handling all sheep to more nearly approach the ideal desired. Additional demonstration tests under careful supervision may be necessary in 1919 but only as a part of the combination deferred and rotation grazing and improved handling of sheep demonstrations on the Medicine Bow and Gunnison Forests. Date of completion, continuous until satisfactory methods are adopted on all National Forests.

Forest officers administering grazing under the general direction of District and Washington offices.

239. Range management to avoid loss of stock due to starvation, disease, etc.

The Jornada Range Reserve of 200,000 acres, and the Santa Rita Range Reserve of 50,000 acres so divided as to reserve a portion of each area for use primarily during the dry period of spring and early summer. This plan makes it possible to reserve native forage to help tide the stock over the critical period of the year. At the Jornada Reserve 40,000 acres of grama grass range thus reserved has aided materially in reducing loss of cows from starvation during the past four years.

To supplement and further increase the reserved feed for breeding stock during critical periods, about one-third of the carrying capacity of the Jornada Reserve is used for grazing steers. During unfavorable seasons the number of steers can be reduced as necessary to provide additional range for the breeding stock. During 1917, for example, all of the steers were sold, thus providing one-third more range for the breeding stock. These steers are usually held on pastures which are suitable for grazing during the critical dry period in spring and early summer. This phase of management has materially aided in maintaining the breeding herd without loss and necessity of forced sales.

To supplement the range provided in the ways outlined above, native plants have been tried out both as hay and ensilage. Tobosa grass cut and fed as hay, and Tobosa grass tried as ensilage in 1916 proved of doubtful value. One hundred and fifty tons of soapweed was preserved in a pit silo, and a small amount fed in the spring of 1916. The results were promising. During the fall and winter of 1917 a special ensilage machine was designed and constructed, and was placed in operation on the Jornada Reserve in January, 1918, to cut the soapweed ready for feeding green. More than 1000 poor cows were fed soapweed and cottonseed products on the Jornada Reserve between January 1 and August 1,

1918. This feeding saved probably 500 head from starvation. This practice was taken up by other stockmen and it is estimated that over 100 herds were being fed soapweed by June 1, 1918. U. S. Department of Agriculture Bulletin 745, giving the results of this work, was published. The soapweed should be fed only during critical periods as the plants are slow growing. This will give the plants a chance to grow an additional crop after once being cut.

The native forage and soapweed for best results need to be supplemented by concentrated feeds. During the past three winters poor cows, bulls, and a great many calves have been fed cottonseed cake. This feeding is an important factor in reducing losses at the Reserve.

Prior to 1915 losses from blackleg at the Reserve were heavy. In 1915 a systematic campaign of vaccination was initiated, with the result that the loss has been materially decreased. In 1917, 800 doses of Germ Free Vaccine were used. This new vaccine gave excellent results and did away with the necessity for vaccinating three or four times before the animals are two years old.

The net result of the foregoing features of management to avoid loss has been that the losses from all causes at the Jornada Reserve were only 1.9 per cent in 1915, 1.5 per cent in 1916, 1.8 per cent during the bad year of 1917 and in 1918, 3.5 per cent. The best available figures for New Mexico as a whole show average losses of 10.6 per cent for calves, 5.6 per cent for yearlings, and 5.6 per cent for stock over two years of age. For 1917 the average was about 15 per cent and in 1918 from 15 to 50 per cent. This reduction in loss through better management is extremely important and stockmen are becoming interested in the improved management.

It is planned to continue with the investigations along the above lines. The amount of concentrated feed will probably be increased and the studies to perfect methods of using soapweed will be continued. Also the systematic vaccination of stock under 20 months of age will be continued, and it is probable that the new blackleg vaccine will be used in greater amount with a view to further reducing the losses from blackleg and at the same time reducing the cost of handling the stock in connection with vaccinating. Work along these various lines will be intensified as far as seems practicable under management on a large range unit. Similar tests which will be comparable to management conditions on a grazing homestead have been initiated with 40 head of breeding stock and will be continued. It is probable that a statement will be prepared for publication in 1919. Date of completion, continuous as long as the Reserves are under experimental management.

Assigned to C. L. Forsling and R. R. Hill.

240. Improving the grade of stock and increasing the calf crop by improved range management in southern New Mexico and southern Arizona.

At the Jornada Range Reserve 500 breeding cows were segregated from all other stock in the fall of 1915. In 1917 between 50 and 75 head of the poorest cows were culled out and replaced by selected heifers. An additional cull was made in 1918. This plan will be followed, gradually replacing the poor cows by selected heifers from the increase of the herd. The heifers will be held away from bulls until they are from twenty months to two years of age. Purebred Hereford bulls were purchased for this herd in 1915. Additional purebred bulls have been purchased each year since, the best ones being retained for this herd and the others used in the main herd.

The main herd is approximately 1500 breeding cows. From this herd about 1000 poor grade, off-colored, and old cows have been culled out and sold. An equal number of selected heifers have been placed in the herd. Purebred bulls have been used exclusively during the past three years. The average grade of the breeding cows has been greatly improved and about 90 per cent of the calves are now straight white face of good form. Yearling steers sold from the Reserve in 1917 brought from $2.50 to $5 more per head than steers of the same age from the herd on the outside range.

In 1916 the calf crop in the 500 head herd was 81 per cent; in 1917, 68.2 per cent; in 1918, 80 per cent, making an average of approximately 76 per cent for the three years. The calf crop for the main herd in 1916 was 69.2 per cent; in 1917, 63.2 per cent; in 1918, 55.4 per cent, an average of approximately 63 per cent for the three years. This shows a big advantage in favor of the smaller herd with better care. The average calf crop for southern New Mexico in 1916 was not over 60 per cent, in 1917 it is estimated at 25 to 40 per cent, and in 1918 from 20 to 40 per cent.

At the Santa Rita Reserve similar investigations were begun in 1916. Drought and lack of facilities for handling the stock year-long have interfered with the investigations. However, sufficient data have been secured to show possibilities similar to those shown at the Jornada Reserve in the increasing of the calf crop and improving the grade of stock. In two of the herds, the poor grade bulls used prior to 1916 have been replaced by registered Herefords; the breeding cows are being improved in grade by selling off poor grade and off-colors as rapidly as better grade heifers are available to replace them.

The calf crop has averaged approximately 70 per cent for three years. For one herd of 100 to 250 cows the calf crop in 1916 was 85.7 per cent; in 1917, 81.8 per cent, and in 1918, 83.1 per cent. The average calf crop for Arizona was given as 57 per cent by reports from stockmen in 1914.

The improvement in grade and increase in calf crop has been facilitated greatly by the increased feeding and reservation of native forage as outlined under the project. Range Management to avoid losses of stock; keeping the cows in thrifty condition and taking good care of the bulls being important factors in securing a large calf crop. The increased water development, segregation of breeding stock from dry stock, and general care of the herds have aided in securing the increased calf crop. The investigation under way will be continued.

At the Jornada Reserve an additional test in management with 40 cows was started in 1917. This test was interfered with by the severe drought in 1918 but will be continued as soon as conditions warrant. The favorable results from the 500 head herd have convinced our cooperator, Mr. C. T. Turney, that it will pay him to initiate similar management with the main herd of 1500 head. As soon as the drought is broken, therefore, the cows in the main herd will be carefully selected and will be given better care than in the past. If these three tests can be carried out as planned we will secure records for range herds of 40 head, 500 head, 1000 to 1500 head.

At the Santa Rita Range Reserve difficulty is still anticipated in securing adequate control of the stock and breeding operations, owing to the difficulty of an assured year-long water supply adequate to warrant proper division of the range to accomplish the most desirable plans of management, and to the fact that there are four cooperators. There has, however, been a marked improvement in the stock since 1915 and it is believed that improvement will be still more rapid in the next few years regardless of the difficulties. Date of completion: Continuous during the periods that the Jornada and Santa Rita Range Reserves are under experimental management.

Assigned to J. T. Jardine, C. L. Forsling and R. R. Hill.

241. Cost of handling stock under pasture and improved methods of management as compared with the cost on open range.

A record of the cost of operating the Jornada Range Reserve has been kept for four years, and attempt has been made to secure data on the cost of handling similar outfits under open range conditions. It is difficult to secure figures for the outside range, however. The costs have not been analyzed to date, and probably will not be for a year or two unless special need arises for specific figures along this line. Similar records are being collected on the Santa Rita Reserve.

Careful records will be kept as to the cost of management of the Reserves as a whole, and cost of different phases of management. Similar data will be collected as far as practicable for outside range conditions. Date of completion, continuous during the period of the Jornada and Santa Rita Range Reserves are under experimental management.

Assigned to C. L. Forsling and R. R. Hill.

242. Handling stock on browse range.

To determine primarily (1) whether stock, particularly cattle and sheep, can economically utilize range where the cover consists practically of a pure stand of browse composed of one or several palatable species, (2) what basis should be used in estimating the carrying capacity of such lands for the different classes of stock, and (3) what effect the class of stock grazed may have on the permanency of the broader browse types. It has been suggested that where browse constitutes 75 per cent or more of the forage the vegetation other than browse, regardless of species, may be disregarded in deciding the intensity of grazing for the type. On the other hand some argue that this practice would result in a destruction of the herbaceous cover and hence render the range of no value for the grazing of cattle. The whole problem requires careful investigation.

It is the plan to experiment with both cattle and sheep. Since it will be necessary to have complete control of the stock they will be handled in pastures. During 1919 the problem will be looked into on the Dixie Forest, and the locations for the pastures selected. A general survey of the browse utilization on the Tonto Forest will be made and areas selected for detailed investigation. Date of completion, a single season would afford results of much immediate practical value. Three seasons would probably suffice in which to complete the project.

Assigned to A. W. Sampson and M. W. Talbot. Will be extended to District 5 later.

CARRYING CAPACITY

243. Carrying capacity, all Districts.

Range for four bands of sheep under observation, Deerlodge Forest 1912–13; 3 bands 1914; 2 bands 1915–16; 8 bands 1912–13, 6 bands 1914, and 4 bands in 1915 on Madison Forest. Range for 250 cattle under observation 1914–16 on Lewis and Clark Forest. In 1918 a Grazing Assistant was assigned to the cattle carrying capacity study on the Lewis and Clark Forest and report prepared. In this test, as in many of the other observations which have been taken, difficulty has been encountered in securing adequate control of the stock.

Observations on a number of pastures in District 3 in 1914 and 1915, but no conclusive results secured. Observations on three bands of sheep on Targhee in 1913 and 1914; 1 band on Manti 1913; 3 bands in 1914, and 2 bands in 1915–16; 2 bands on Caribou in 1913 and 1914, 3 bands in 1915, 5 in 1916; 2 bands on Fillmore in 1916. During 1917 and 1918 a great deal of data have been accumulated by some 20 odd men assigned to special range inspection or extensive reconnaissance. Carrying capacity has been estimated by allotments and units, and these estimates will be used as a check in actual grazing management. Revision in the figures will be made as improvement in management becomes effective. Several additional pastures have been placed under observation. Short article published in National Sheep Breeder and a chapter included in U. S. Department of Agriculture Bulletin 790 on Range Management.

The collection of data by Grazing Examiners on special range inspection will be continued. The carrying capacity study on the Lewis and Clark will be discontinued as an intensive study. Data secured from observation by local officers and permittees will be reported. It was planned during the winter of 1918–19 to have the Grazing Examiners in each District bring together all the results on carrying capacity from the special studies and from intensive and extensive reconnaissance, the idea being to prepare a preliminary table of carrying capacity figures for each District and for Forests by groups. This plan was interfered with by a number of men leaving for military service. It is hoped that this part of the project can be undertaken in 1919. Following such a compilation a more definite program for carrying capacity studies will be developed for adoption as funds and men are available. Carrying capacity will be a problem of importance for many years, and, therefore must be continuous. Specific studies may be completed and others initiated, but the main study of carrying capacity will go on as it is a line of work rather than a specific study in a given locality.

Assigned to Grazing Examiners under the general direction of J. T. Jardine.

244. Utilization of bunchgrass ranges, District 3.

Observations made on three pastures on the Apache Forest in 1914 and 1915. General observations on the Coconino and other Forests. A drift fence on the Apache designed to hold stock on the bunch-grass range in question nearly completed in 1917, and valuable data as to the value of bunch-grass range for cattle has been secured.

The bunch-grass range placed under use for cattle grazing by the construction of the Apache drift fence will be inspected from time to time, and observations will be made on other Forests in the District. Construction of range improvements and improvement in control of stock are essential to successful study of this problem, and the progress made will depend upon the rapidity with which the necessary improvements and control of stock are secured. The study will be continued until satisfactory utilization of the bunchgrass ranges is secured, or until satisfactory utilization is dependent upon range improvements entirely rather than as at present upon lack of information as to the value of such range and satisfactory methods of utilization.

Assigned to M. W. Talbot

245. Carrying capacity of range in southern New Mexico and southern Arizona.

Records of the time of grazing and animal days feed furnished by each of 13 pastures on the Jornada Range Reserve have been kept for five years. The greater part of the area has been classified into range types, so as to determine carrying capacity as a whole for the Reserve and carrying capacity by large range types. Data for three years were published in U. S. Department of Agriculture Bulletin No. 588. Similar work is being done at the Santa Rita Range Reserve, and records are available for 9 years on two small pastures and for two years on the entire 50,000 acres.

On the Jornada Range Reserve especially the comparative carrying capacity of range under fenced control and proper management, and range not under fence is being studied. The drought of 1917–18 has greatly influenced results. A year of recovery will be necessary before the real significance of drought as a factor in carrying capacity over a period of years can be decided.

The investigations as outlined above will be continued and will be itensified as rapidly as facilities for a more specific study of carrying capacity by range types are provided. The observations will be extended to cover more range throughout southern New Mexico and southern Arizona as rapidly as possible. The results of these studies will be combined with carrying capacity data from District 3 eventually. Date of completion, continues as long as the Reserves are under experimental management.

Assigned to J. T. Jardine, C. L. Forsling and R. R. Hill.

METHODS OF DEVELOPING STOCK WATERING PLACES

246. Number, distribution, and cost of watering places on cattle ranges of the Southwest.

During the past four years careful studies have been made at the Jornada Range Reserve to determine the distance that permanent watering places can be apart and still secure reasonably efficient utilization of the range. This distance has tentatively been decided as 5 miles. To supplement such existing permanent watering places, numerous small tanks have been constructed on the Jornada Reserve, and it is found that where conditions are favorable to the construction of such tanks and accumulation of water in them to be used during a portion of the year, the money spent for such water development is a good investment. This supplemental water results in better distribution of the stock, more equal utilization of the range more succulent feed, less waste of energy in travel by stock, and the possible protection of range around permanent waters for use during critical periods when the temporary watering places go dry.

In District 3 observations of water distribution and methods of developing water on the National Forest ranges have been made over a period of years with a view to eventually formulating effective methods of water development and effective distribution of watering places to secure maximum utilization of the range consistent with the difficulty and cost of water development.

The investigations at the Jornada Reserve will be continued to determine the difference in carrying capacity of range where the distance between watering places is variable. Methods of developing water and costs, especially of tank construction, will be further observed. The observations on National Forest ranges will be continued. Similar observations to those at the Jornada are being conducted at the Santa Rita Range Reserve and will be continued.

Assigned to C. L. Forsling, R. R. Hill and M. W. Talbot.

POISONOUS PLANTS

247. Eradication of poisonous and unpalatable plants from the range, all Districts.

At the Great Basin Experiment Station studies have been under way to determine the practicability of eradicating larkspur by cutting above ground and by grubbing since 1913. On an experimental basis the Experiment Station has concluded that cutting above ground four times during a period of three years is the cheapest way of eradicating larkspur on areas relatively free from rock, brush, or timber. The Station, however, advocates the test of this method on a practical basis to secure a comparison of costs with effectiveness of grubbing before the cutting method is finally advocated for use under practical range conditions.

As early as 1913 minor tests in the eradication of larkspur by grubbing were initiated on the Forests in California In 1913–14–15 and 1916 eradication by this method was tested out and greatly enlarged until in 1915 a practical test by grubbing out 68 acres of larkspur from a range unit of about 14,000 acres was undertaken on the Stanislaus Forest. The eradication was approximately 95 per cent effective, and the losses of live stock were reduced below the average losses in previous years sufficient to more than cover the cost of eradication. During 1915, 1916, and 1917 similar work was done on a great many Forests in Districts 2, 4, and 5. A total of about 1,900 acres of larkspur was eradicated during this period. In 1918 the eradication planned was interfered with by difficulty of securing labor. In spite of this fact, however, several hundred acres of larkspur were grubbed. With few exceptions the value of the stock saved as a result of the eradication work has been sufficient in one year to cover from one-third to two times the cost of eradication. The methods developed and the results secured are so satisfactory that stockmen generally are willing to contribute 50 per cent of the cost of eradicating the plants and in some cases are undertaking the eradication of their own accord. Farmers' Bulletin 826 presents the methods of eradication and results secured.

It is planned to continue larkspur eradication as a range improvement project in cooperation with stockmen as fast as funds are available. The work will be done under the direction of trained men as far as practicable, and special examination will be made in advance of eradication so as to make the actual work of grubbing out the plants as effective as possible, and avoid undertaking eradication on areas where the probable saving in live stock as a result of eradication will not be sufficient to justify the cost of the grubbing. As soon as it is feasible to do so, a practical demonstration of eradicating larkspur by cutting, in accordance with plans developed by the Great Basin Experiment Station, will be undertaken.

Observations have been made in District 3 to determine the possibility of eradicating loco by grubbing, and the possibility of reducing losses from loco poisoning by a change in the method of range management and the time of grazing. A small amount of study has been devoted to the problem of eradicating death camas and sneezeweed. Observations along these lines will be continued, and if the general conclusions appear to warrant it further investigations will be initiated as soon as funds and men are available. It is probable that the problem of successful management of areas of range infested with loco will be given a good deal of attention during 1919. Date of completion; the work of eradicating larkspur will undoubtedly be continued until the practical possibilities of eliminating losses of live stock in this way have been exhausted. Investigations as to methods, costs, etc., will probably be discontinued within the next two years, during which time it is believed that methods will be sufficiently standardized to obviate the necessity for further special study. Work on eradication of other poisonous plants will probably continue indefinitely.

Assigned to **A.** W. Sampson, and Grazing Examiners.

TYPES

248. Climatic characteristics of vegetative belts on the Manti Forest.

Climatic records of air temperatures, precipitation, sunshine, and wind velocity have been made during the past four years at three stations. One station is located in the oak brush type, one in the aspen-fir, and one in the spruce type. During 1917 plants were grown at the three stations to ascertain the relation between certain climatic factors and the plant growth. The results are reported in U. S. Department of Agriculture Bulletin 700, "Climate and Plant Growth in Certain Vegetative Associations."

During 1919 the observations at the three stations will be continued if available help will permit. Date of completion, indefinite.

Assigned to A. W. Sampson.

EXHIBITS

249. Exhibits, illustrative features for educational purposes (cooperation with grazing studies), Great Basin Expt. Station.

The value of exhibits, especially the more permanent illustrations is well known. Grazing, so far as concerns numerous well tested methods of improved range management, is not well represented in way of exhibits yet many of the more important principles can be readily illustrated. There is, of course, nothing new or original about this work; it merely affords an additional means of publishing results.

The more permanent type of illustrations, such as those made from wood pulp, for instance, are most valuable. Pictures, graphs, and lantern slides are also proposed, however. The Office of Education will cooperate with the Branch of Grazing in the preparation of exhibits. Grazing will furnish the material (photographs, graphs, sketches, etc.), while the Office of Education will be responsible for the final preparation of the exhibit. Date of completion, continuous. It should be the aim to prepare exhibits as important new principles are developed.

Assigned to J. T. Jardine, A. W. Sampson, and Grazing Examiners.

ECONOMIC INVESTIGATIONS

250. **Study of pine lands of the South Atlantic and Gulf States (project E-2, D-8; combination of former projects M-10, D-8 and Z-9, D-8).** Possibilities of the South for continuing lumber and turpentine production, and as an outlet for the growing demand for agricultural and grazing land: (*a*) segregation of agricultural and forest lands; (*b*) fire protection; (*c*) advice to owners on management of forest lands.

Extension of the study begun in 1914 by E. S. Bryant in the Alleghany mining belt. The southern pine region is considered the most important field for this study on account of the large amounts of cut-over lands and the need for their development along sound economic lines to prevent their becoming non-productive.

Assigned to Austin Cary and W. R. Mattoon.

251. **Possibilities of logged-off land for forestry (project E-3, D-8; formerly Z-10, D-8, special studies).**

Begun 1916. Completed 1918, after Mr. MacKaye's transfer to the Department of Labor, and results published in Dept. of Labor Bulletin "Employment and Natural Resources," 1919.

Assigned to Benton MacKaye.

Completed.

252. **Study of privately owned cut-over lands in the Pacific Northwest (project E-4, D-1, 4, 5, 6, 8; formerly Z-11, D-1, 4, 5, 6, 8, special studies).** To determine the character, extent, economic significance, and possible use of cut-over lands under private ownership in the Pacific Northwest, whether denuded or covered with second growth, with special reference to their value for the practice of forestry.

Begun as a project, in 1917, although considerable information previously gathered in the lumber industry study was utilized.

Field work completed and report prepared. Report will perhaps be issued as a joint publication by the Departments of Labor and Agriculture (Forest Service).

Assigned to S. T. Dana, in cooperation with the Districts concerned.

253. **Study of Government control of privately owned timberlands in Europe (project E-5, D-8; formerly Z-12, D-8, special studies).**

Begun in 1917. Publication: "Public Control of Private Forests in Norway," by S. T. Dana, Jour. Forestry, May, 1919, Vol. 17, No. 5: 497–502.

Study of all available literature on the subject as a basis for a final report.

Assigned to R. Zon and S. T. Dana.

254. **Economic study of the lumber industry (project E-6, D-8; extended to include former project L-6, D-8).** To ascertain the fundamental conditions controlling the ownership of stumpage and the production and marketing of lumber with special reference to their bearing upon

conservation and timber supply, upon stable conditions in the industry, and upon forestry; and also to present a historic and economic analysis of the public timber resources of the United States with special reference to the development of a definite timber sale policy; to state the present policy and indicate the opportunities for the purchase of timber from the National Forests; to keep in touch with current economic developments in the lumber industry with particular reference to their bearing upon forestry.

Begun 1914. Stumpage and manufacturing conditions were studied in the Pacific Northwest, California, the Inland Empire, and the South. Distribution was studied in the Middle West. The following reports have been published: "Some Public and Economic Aspects of the Lumber Industry," by W. B. Greeley; "Distribution of Softwood Lumber in the Middle West, Wholesale Distribution, Retail Distribution," by O. M. Butler; "Substitution of Other Materials for Wood," by Rolf Thelen. (Reports 114, 115, 116 and 117, U. S. Dept. of Agr.). Other publications were planned to cover the technical and forestry phases of the question. Regional stumpage and manufacturing reports have been practically completed. Some of the technical reports may be printed during the year.

Reports under way to be completed as soon as possible; continuation of the study to keep in general touch with developments in the lumber industry, this to be expanded as soon as facilities permit to cover special phases. Reports in preparation and assignments:

Forestry and the Lumber Industry, assigned to H. S. Graves.

Timber Ownership and Lumber Production in the Southern Pine Region, assigned to C. S. Smith and R. C. Bryant.

In the Douglas Fir Region, assigned to Austin Cary.
In the Inland Empire, assigned to D. T. Mason.
In California, assigned to C. S. Smith.
Public Timber and Its Uses, assigned to W. B. Greeley.

Utilization of Low-grade Lumber and Mill Waste, assigned to H. F. Weiss.

Adaptation of Lumber Manufacture in Grading to the Requirements of Consumers, assigned to H. S. Betts.

255. Economic study of the pulp and paper industry.
To ascertain the fundamental conditions controlling the ownership of stumpage and the production and marketing of pulp and paper with special reference to their bearing upon conservation and timber supply and upon forestry; to keep in touch with current economic developments in the pulp and paper industry with particular reference to their bearing upon forestry.

Begun in 1918. A few short articles published.
Continue in accordance with the general plan.
Assigned to Austin F. Hawes.

256. Market studies (project E-7, D-1, 2, 3, 4, 5, 6, 7, 8; formerly L-5). To ascertain: (1) consumption of forest products and location and nature of demands in regions adjoining the National Forests; (2) trade and transportation conditions which now govern source of timber supplying this demand; (3) in localities where National Forest timber is not utilized, the causes which prevent such utilization; and to outline measures for extending local use; (4) to serve as a basis in part for plans of management on the National Forests.

Much information obtained in all Districts before the war. Reports published for Oregon and Washington showing production and consumption of forest products in these States. Districts 1 and 3, in cooperation with the Forest Products Laboratory, conducted investigations to determine possibilities of wider use of local timbers for mining, causes of breakage of western yellow pine for ties, and value of white fir for ties.

Work will, if possible, be taken up during the year in all the National Forest Districts. Upon completion of District studies a general report will be prepared outlining the services of the National Forests in supplying local markets.

Assigned to all Districts and Forest Products Laboratory.

257. **Forest products statistics (project E-8, D-8).** To collect (1) annual statistics on production of lumber, lath, and shingles, pulpwood consumption and wood pulp production, tie and pole consumption and preservative treatment, and fuel wood production; (2) periodic statistics of production or consumption of other forest products such as cooperage, veneer, etc.; (3) stumpage and lumber prices as an indication of market trend and as a basis for National Forest appraisals.

Lumber production statistics collected and reports published annually since 1905 except in decennial census years when the work was done by the Bureau of the Census pulpwood and wood pulp statistics since 1916; tie and pole preservative statistics since 1915; wood fuel statistics since 1916 in cooperation with the Bureau of Statistics; cooperage statistics collected in 1918; lumber price statistics since 1909; stumpage prices since 1913. Except on prices the collection of statistics for 1919 will be in cooperation with the Bureau of the Census.

Collection of statistics by the Forest Service will be resumed in 1920. During the current year a general summary will be prepared incorporating up to the present time all available statistics on production or consumption as well as those on destruction of timber resources, as an indication of the trend of the depletion of timber resources.

Assigned to F. H. Smith, A. H. Pierson, R. K. Helphenstine, Jr., in cooperation with District offices.

258. **Forests and forest products in the war (project E-9, D-8).** To show the value of forests and forest products in connection with the various phases of warfare, the extent of their use, and the bearing upon forestry.

Collection of data begun in 1919.

It is hoped to complete and publish a report during the current year.

Assigned to E. H. Clapp.

259. **Woodlot economic survey (project E-10, D-8).** To secure first-hand data to show the value of farm woodlands and their place in the scheme of farm management in different representative sections of the eastern United States; specifically, to determine the importance of

farm timber in supplying the farm with wood products, its possibility of supplying work in slack seasons, its cost as a farm enterprise, and the value of the woodlot products obtained. See also related project M-5, D-8 (woodlot management studies).

Begun in 1915. From 1915 to 1917 more than 1000 farms were canvassed in the following counties:

Massachusetts,	Windham Co.	Iowa,	Jones Co.
Vermont,	Franklin Co.	Nebraska,	Gage Co.
Pennsylvania,	Chester Co.	North Carolina,	Randolph Co.
Indiana,	Madison Co.	South Carolina,	Marlboro Co.
Indiana,	Jackson Co.	Tennessee,	Rutherford Co.
Indiana,	Kosciusko Co.	Alabama,	Morgan Co.
Wisconsin,	Marathon Co.	Louisiana,	Ouachita Co.
Minnesota,	McCloud Co.	Missouri,	Barry Co.

The resulting data were compiled, reviewed by the Office of Farm Management, and are now put in shape for the final report. In 1919 additional data were secured, in accordance with the general plan, on about 100 farms in Geauga County, Ohio, and Butler County, Pennsylvania. These data have not yet been tabulated.

The original plan confined the study largely to the more highly developed and prosperous agricultural regions with the most fertile soil, in which the investigations would not reflect the service of the woodlands to the best advantage. It is, therefore, desirable to cover also the regions where farming is less developed, either because of less fertile soil, more rugged topography, lack of drainage, or other factors; and it is proposed to extend the study to the following regions, in order of importance: (1) Pennsylvania and New England (except possibly Maine). (2) The Piedmont area of North Carolina and also additional areas in northern Alabama, nothern Louisiana, the Ozark region of Missouri, and in northern Wisconsin. (3) New York, southern Ohio, Appalachian parts of Tennessee, southwestern Virginia, West Virginia, and northern Georgia.

Assigned to E. R. Hodson, for the Forest Service, in cooperation with the Office of Farm Management.

260. Pulp and paper possibilities of the National Forests (project L-193). Surveys have been made and considerable data have been gathered to show the economic aspects of the development of pulp and paper plants to utilize woods from the National Forests.

Continue arranging and analyzing data as time permits.

Assigned to Forest Products Laboratory.

261. Wood-using industries of New York States (project U-59). A former report on the wood-using industry of New York State is considerably out of date. The study is being made in cooperation with Syracuse University.

A new study of State industries is under way. The former report will be revised and additional emphasis will be laid on the relation between the industries and the forests of the State.

Assigned to Washington Office of Forest Products.

BUREAU OF PLANT INDUSTRY

WILLIAM A. TAYLOR, Chief

INVESTIGATIONS IN FOREST PATHOLOGY

Haven Metcalf in charge

262. Pathological problems in wood conservation, in cooperation with the Forest Products Laboratory. To work out miscellaneous problems on the pathological aspects of wood conservation. Studies are made of the specific toxicity of wood preservatives against certain timber-rotting fungi; of the causes, conditions, and means of control of decay in building timbers under yard and storage conditions, and in mining timbers; of the histology and cytology of wood rots in general; of the natural resistance of various species of wood to decay; and of the relation of moisture, temperature, and other surrounding conditions to decay.

Status.—The work was begun in 1909 and is carried on at the Forest Products Laboratory at Madison, Wisconsin.

Results.—Definite knowledge has been obtained of the causes of certain types of decay of mining timbers, of the causes and conditions of various wood rots, and of the specific action of various preservatives. A method has been developed for quickly testing the toxicity of preservatives against pure cultures of wood-destroying fungi (method and tests published in Department Bulletin 227). About 6000 such tests have been completed. A method of testing the toxicity of heavy oils has been invented. Studies of conditions surrounding structural timber in storage show that decay in storage is preventable by slight and perfectly practicable changes in lumber-yard management, as set forth in Department Bulletin 510. Full data have been secured on the temperature range of 73 species of wood-destroying fungi. Practical results are reflected in work of the Forest Products Laboratory.

To be continued along the same lines.

Assigned to C. J. Humphrey and Paul V. Siggers.

263. Diseases of forest nursery stock. Investigation of these diseases with reference to control. This project involves the testing of the effects of various soil fungicides and amendments, of spraying, and of modification of nursery practice on "damping-off" and other nursery diseases; also greenhouse and laboratory experiments on the life history of the parasites which cause "damping-off" and the factors affecting them, with a view to the development of new control methods.

Status.—Begun in 1910. The work is done in cooperation with the Forest Service and private nurserymen. Field tests at Cass Lake, Minn., and Halsey and Nenzil, Nebr., laboratory and greenhouse work at Washington, D. C.

Results.—"Blight" of coniferous seedlings has been controlled by change in methods of watering. "Damping-off" on most soils, both in the East and West, has been controlled by treatment with sulphuric acid; amounts needed for a number of different localities have been determined. Treatment with copper sulphate has been developed in alkaline soils on which acid is not satisfactory. The weed destruction alone pays the cost of treatment at many nurseries. Part of the results are given in Department Bulletin 453. A disease similar to "damping-off," but caused instead by excessive soil heat, has been studied, and the distinctive symptoms and preventive measures have been described in the Journal of Agricultural Research, Vol. 14, No. 13. The cause of the destructive nursery blight on cedars has been discovered, and the experimental work with it is described in the Journal of Agricultural Research, Vol. 10, No. 10. Evidence has been obtained indicating the value of spraying in controlling this disease. At least seven distinct fungi are able to cause "damping-off" of conifers. The identity of certain of the parasites with those causing diseases of crop plants has been demonstrated.

To be discontinued after publication, on account of lack of available investigators.

Assigned to Carl Hartley (resigned) and Annie E. Rathbun.

264. Cooperative field studies and demonstrations in forest pathology. To determine the best methods of controlling forest-tree diseases, particularly in the National Forests. From detailed and statistical studies of diseased stands in typical areas, rotation and cutting cycles based on diseases are established, improved marking and scaling methods developed, and exact percentages determined.

Status.—Begun in 1910. Work is in cooperation with the Forest Service, at Spokane, Washington, Albuquerque, New Mexico, San Francisco, California, and generally throughout National Forest Districts 1, 3, and 5, and a few localities in District 6.

Results.—The "sanitation clause" (Standard Clause No. 57, p. 308, National Forest Manual, Regulations and Instructions), which requires the purchaser in Government timber sales to cut all snags and all defective trees marked and to remove and pay for all merchantable lumber contained in such trees, has been developed by the work under this project. These studies also guide planting plans for the future forest in these particular localities, establish a definite cull percentage in place of an empirical one, and establish definite belts in which empirically found cull percentages may be more accurately applied. Studies of the pathology of the so-called inferior species show in the species so far studied that the inferiority is due to disease susceptibility. The age at which decay reaches practical importance (age of decline, critical age) is determined, which becomes a limiting factor in rotation (Department Bulletin 275). The studies on incense cedar along this line are practically completed. In this species definite external symptoms of rot have been defined which enable the marker and scaler to determine the internal condition of tree and log without cutting, thus saving substantial expense. The discovery of a brush-rotting fungus (Poria sp.) and studies of its activities have led to the substitution of "pulling" brush for piling it in localities in Arizona, New Mexico, and Arkansas, where it is difficult to pile and burn it on account of the shortness of the season during which burning is safe. (This project includes those listed under Forest Service, Protection, Diseases, under the direction of Doctors Meinecke, Weir, and Long.)

More extensive work in this line is planned for District 6.

Assigned to E. P. Meinecke, James R. Weir, W. H. Long and J. S. Boyce.

265. Miscellaneous forest-tree diseases. Investigation, with reference to control, of the nature and life history of various tree diseases and of the effects of smelter fumes, smoke, and gasses upon trees. The usual methods of investigation of plant diseases are applied to forest-tree diseases.

Status.—Begun in 1907. Work is in cooperation with the Forest Service at Washington, D. C., Providence, R. I., Spokane, Wash., Denver, Colo., Albuquerque, N. Mex., and San Francisco, Calif.

Results.—Fundamental contributions have been made to the knowledge of about 50 diseases.

To be continued along the same line.

Assigned to George G. Hedgcock, E. P. Meinecke, Jas. R. Weir, W. H. Long, J. S. Boyce, Ellsworth Bethel, E. C. Hubert, and G. G. Hahn.

266. Miscellaneous imported and epidemic tree diseases. Investigation of the white pine blister rust, the chestnut blight, the pitch-pine blister rust, the European-poplar canker, and other imported and epidemic tree diseases, with reference to their control. In the course of work under other projects, attention is called to these diseases. Their life histories are then studied to find weak points for attack, and their range, origin, and means of spread are determined. Under this project the fundamental problems of spread and adaptation of introduced diseases and the problems of susceptibility of native tree species to foreign diseases are studied.

Status.—Begun in 1907. Work is in cooperation with Federal Horticultural Board; also informal cooperation with States, institutions, private firms, and individuals; at Washington, D. C., Providence, R. I., Bell, Md., Arlington, Va., and various field points throughout the United States.

Results.—The real nature and Asiatic origin of the chestnut blight and its manner of distribution have been determined. Many new facts have been discovered regarding the relation of meteorological conditions to this disease. Extensive destruction of advance infections has been accomplished, which is estimated to have retarded the advance of the disease 15 years. The practical utilization of blight-killed trees has been made possible. Resistant and immune Asiatic strains have been discovered. A chinquapin-Japanese chestnut hybrid resistant to the chestnut blight has been developed and is being propagated. Resistant individuals of the American chestnut have been discovered and stock from these is being propagated. Eleven newly imported diseases have been studied and destroyed so far as found. New and decisive methods, involving new symptoms, have been discovered for identifying doubtful cases of white-pine blister rust. All native Ribes tested (about 70 species) have been found susceptible to blister rust. The blister rust has been shown to be apparently taking on new characters and to be apparently more virulent in America than in Europe. Overwintering of viable spores on Ribes has been demonstrated. The distance of spread of spores from Ribes to pines has been shown to be short, making possible the methods of local control now in use. The rust on Ribes in Colorado, at first believed to be the white-pine blister rust, has been shown to be a relatively harmless native rust, with its alternate stage on pinon pine. The work done under this project has resulted in a marked change in the public attitude toward such diseases, involving general recognition of the dangers of importation of ornamental and forest-tree nursery stock.

Future work will be largely limited to studies and development of strains of chestnut resistant to blight, and to further studies of the white pine blister rust.

Assigned to Haven Metcalf, Perley Spaulding, Reginald H. Colley, G. F. Gravatt, and Minnie W. Taylor.

BLISTER RUST CONTROL

Samuel B. Detwiler in charge

267. Control of the white pine blister rust. Local control areas are established in regions where Ribes infection is general. Wild and cultivated Ribes are destroyed in these areas in cooperation with and under legal authority of the States concerned. Specially selected demonstration areas are used to determine the most efficient methods, cost, and practicability of wild Ribes eradication. Eradication of beds of skunk currant and dense wild gooseberry growth by means of various chemicals is being undertaken in a small way. Shipments and reshipments of 5-needle pine stock from foreign and domestic nurseries, known or suspected of being infected are traced and inspected. When the disease is found the diseased trees, and nearby Ribes when necessary, are destroyed by the appropriate State officials; when legally or otherwise possible, the entire shipment is destroyed. Systematic scouting for diseased pines and Ribes also is conducted outside the region of general infection wherever there is a possibility that "spot infections" of the blister rust exist. Eradication of these secondary infections is attempted by removal of all pines or Ribes, or both if necessary, under State authority.

Status.—Begun in 1916. Formal or informal cooperation has been established with all States except Florida, Alabama, Mississippi, and Louisiana, where there are no 5-needle pine interests. In the New England States, New York, Pennsylvania, Wisconsin and Minnesota, control work is done on the basis of one dollar spent from Federal funds for each dollar spent by State and Town authorities. In all cases eradication is done under State authority, the Bureau of Plant Industry assuming responsibility only for locating the disease.

The work is conducted wherever the white pine blister rust occurs or is suspected to be present, particularly throughout the range of 5-needle pines. Inspection of nursery stock and plantations is carried on chiefly in New Jersey, Pennsylvania, Delaware, Maryland, the southern Appalachian region, the Middle West and the far West. Experimental control and demonstration Ribes eradication areas are located in the New England States and northeastern New York. Similar areas will soon be established in Wisconsin and Minnesota.

Results.—Blister rust infection on Ribes is general in the New England States and northeastern New York. Many widely distributed incipient pine infections are beginning to appear as a result of heavy Ribes infection in 1915 and 1916; but the disease has not yet had time to produce severe damage to pine on a large scale. Infected areas vary in size from a few pine trees within a hundred feet of single infected Ribes to over 50 per cent of the pine within a radius of one-half mile from large bodies of diseased cultivated bushes. Strip surveys show that 25 per cent of the native pines in an area of 72 square miles in northern New Hampshire are infected with blister rust, due to wild gooseberries averaging about 30 bushes per acre. The oldest infection found on this area occurred in 1906. On a strip line 30–$^7/_8$ miles long run from Lisbon to Woodsville and Piermont, New Hampshire, 2.4 per cent of the pines were found infected.

During the past season, the results of intensive and extensive scouting in Minnesota and Wisconsin have shown that the disease is firmly established on pine and Ribes in both States. Blister rust was found either on pine or Ribes, or on both hosts, in nine counties in Wisconsin and fourteen counties in Minnesota. In some of these counties it was so generally distributed as to make the possibility of eradication hopeless. The policy of eradication that has been in force hitherto in these States, has been abandoned and in the future the work will be placed on a local control basis, as in the New England States and New York.

In the New England States and New York the work is devoted almost entirely to perfecting cheap and effective methods of destroying wild Ribes; to practical demonstration of these methods on local control areas; and to the encouragement of effective local eradication of Ribes in cooperation with towns, associations, and individuals. During the past year, the interest of these local cooperating agencies has been very encouraging. They have appropriated about twenty-five thousand dollars for the protection of their pines by the eradication of Ribes and the outlook for further cooperation of this sort is favorable.

Experience thus far gained on demonstration and local control areas has definitely proved that under normal conditions, at least 95 per cent of the wild Ribes on a given area can be permanently removed at a cost ranging from 5 cents to $1.50 per acre. Improved methods of locating and uprooting Ribes bushes are responsible for reducing the average labor cost in New England from 44 cents per acre in 1918 to 24 cents per acre in 1919. Intensive scouting showed that no pine infections had taken place on four control areas on which currants and gooseberries were destroyed in 1916 and 1917.

Intensive studies of pine infection centers have been made to obtain data on the distance to which Ribes will infect pine. Under ordinary conditions the removal of Ribes within a distance of 200 to 300 yards of pine will insure its commercial growth.

Various chemicals and sprays are being tested to find a cheap and practical means of effectively killing wild Ribes. Satisfactory progress has been made and the results obtained indicate that dip oil, fuel oil, and possibly sodium arsenite, can be used economically to destroy dense growths of Ribes where the cost of hand-pulling is excessive.

Inspection of nursery stock, pine plantations and general scouting for the disease on pine and Ribes resulted in the location of one diseased planted tree in Michigan and one infected patch of cultivated Ribes in New Jersey. The results of inspecting thousands of planted pine and Ribes in the far western States indicate that this region is free from white pine blister rust. Continued scouting in these States is most important and is being actively pursued. Six violations of the quarantine, prohibiting shipments of pine and Ribes from the States east of and including Minnesota, Iowa, Missouri, Arkansas, and Louisiana, to points west of those States, have been discovered the past season. This shows the possibility of the disease reaching the important pine forests of the west and emphasizes the necessity of strict enforcement of this quarantine.

Future work to be continued along same lines with special effort toward securing removal of currant and gooseberry bushes from the vicinity of valuable pine areas in infected regions before further damage from the blister rust occurs.

Assigned to S. B. Detwiler, Roy G. Pierce, J. F. Martin, A. B. Brooks, G. B. Posey, and E. C. Filler.

BUREAU OF ENTOMOLOGY

L. O. HOWARD, Chief

FOREST AND SHADE TREE INSECT INVESTIGATIONS

A. D. Hopkins in charge

(From Program of Work of the United States Department of Agriculture for the Fiscal Year 1919.)

FIELD INVESTIGATIONS

268. Insects affecting forest products. To determine the character, cause, and extent of injuries to crude, finished, and utilized forest products and methods of preventing losses; the relative immunity of different species of wood to attack by termites and other insects; the relative efficiency of chemical preservatives in the treatment of cabinet and other woods against attack by termites, powder-post beetles, and other wood-boring insects; the relative efficiency of chemical preservatives and methods against insect attack on wood set in the ground; the character and extent of the damage caused by termites and practical methods of prevention and control; powder-post injury to seasoned forest products; and damage to poles, posts, mine props, railroad ties, and similar forest products by wood-boring insects.

This is a general project, in which, in addition to the investigations conducted by the leaders, some attention is given to the subject by all members of the staff in connection with their regular field work. The data obtained are submitted to the leaders for study, compilation, and publication. The project includes studies of the character and cause of injuries to recently felled trees, saw logs, round timber, rough timber, and other unseasoned crude products; injuries to seasoned rough and dressed lumber and finished wood material; injuries to construction timbers and other timbers and other wood material used in buildings, bridges, railroad construction, mining, etc.; injury to stored oak and hemlock bark for tanning purposes; injuries to medicinal bark, roots, leaves, etc.; and experiments to determine methods of preventing losses; also investigations of insect galls used for dyes, inks, etc., the insects which produce them, and methods of increasing, collecting, and preserving the products. Special attention is given to investigations and advice with reference to crude and finished products used by the Army and Navy. This involves direct relations with the commissary and supply divisions which have been established.

Status.—This project was begun in 1902. The work is in cooperation with manufacturers and utilizers of forest products; also the Bureau of Chemistry in analyzing preservatives, insect galls, etc. Field station located at East Falls Church, Va. Field of operations, United States; and Central and South America, through correspondence.

Results.—The results of extensive investigations and experiments with preservatives on different kinds of wood have shown that a large percentage of the serious losses hitherto suffered can be prevented. The recommendations and advice of the bureau have been solicited by the commissary departments of the Army and Navy, and in important cases where the advice has been adopted gratifying results in the prevention of losses of valuable crude and finished products have followed. In like manner, the leading manufacturers of vehicles, farm machinery, etc., have sought advice and followed it with most satisfactory results to them. The recommendations based on detailed studies and experiments with poles set in the ground, mine props, railroad ties, telephone and telegraph poles, etc., are being adopted by electrical, mining, and railroad engineers, and a great saving is being effected thereby.

Assigned to A. D. Hopkins, T. E. Snyder, F. C. Craighead, and S. A. Rohwer.

269. Economic investigations of the Scolytid bark and timber beetles of North America. To determine the character and extent of damage caused by these insects to forest growth and forest products, the seasonal histories and habits of the principal species, and practical methods of preventing losses from their attacks.

Procedure.—This is a general project, in which the leader is assisted by other members of the field force in connection with their regular field duties, and includes the collection of material of all stages of the insects and their work, with full field notes on observations relating to seasonal histories, habits, and methods of control, experiments with natural enemies, and verifications of results. These data are submitted to the leader for study, compilation, and publication.

Status.—The work was started in 1890. Cooperation with the Department of the Interior and Forest Service, in the investigation and verification of results of practical control work against the Dendroctonus beetles in the national parks and national forests. The work is conducted from Washington, D. C., and field stations, with field of operations in all the forested areas of the United States.

Results.—The results of the investigations of methods of controlling depredations by bark beetles in the coniferous forests of North America have led to the discovery of practical methods of protecting national, State, and private forests from their most destructive insect enemies. The adoption of the bureau's recommendation based on this discovery has resulted in an estimated saving of not less than $10,000,000 annually in the value of timber protected, at comparatively little cost.

The Dendroctonus beetles have continued to be a menace to the standing pine, spruce, and Douglas fir timber of the Rocky Mountain and Pacific-coast States wherever control measures have not been adopted and carried out to prevent the spread of local outbreaks, and in the aggregate many millions of dollars worth of the best timber has been lost, but wherever the methods that have been determined and advised by this bureau have been adopted and carried out most gratifying results have followed. Especially is this marked in and adjacent to areas where control work has been done in past years in Colorado, Montana, Wyoming, Oregon, and California.

The percentage principle of control has stood the test of another year and appears to be one of the most important practical results attained in the forest-insect work, and much additional confirmatory data have been secured on the host selection principle as related to the economy of insect control.

Under direction of Dr. Hopkins.

270. Economic study of forest Buprestidae or flat-headed borers. Object and procedure same as for preceding project.

Status.—Work begun in 1904 and carried on at Los Gatos, Cal. (field laboratory); field of operations, United States.

Results.—It has been determined that some of the flat-headed borers are primarily destructive to living trees, while others contribute to the death of weakened trees or are destructive to the wood of living and dead timber, and that a large percentage of the losses can be prevented through a practical application of the information already acquired and published. Special progress has been made in the investigation of seasonal histories and habits of many species of flat-headed borers and methods of controlling them. An example of special interest is the investigation of serious damage to plantation of "Australian" in Florida by a species of flat-headed borer (*Chrysobothris impressa* Fabr.) which normally breeds in mangrove. As a result of the investigation, methods of control have been developed and adopted by the principal growers.

Special progress has been made in the studies of Agrilus beetles on the Pacific Coast and in the development of methods of controlling the more important species. It has been determined that the oak twig girdler (Agrilus angelicus), which kills the twigs and small branches on the live oak in California, can be controlled by collecting and burning the infested twigs.

The menace to the oaks on Long Island, N. Y., by the two-lined chestnut borer (*Agrilus bilineatus*) has evidently been reduced to a minimum through the adoption of the methods recommended in connection with the instruction and demonstration work carried on there during the past two years.

Assigned to H. E. Burke, T. E. Snyder, and W. S. Fisher.

271. Economic study of forest Cerambycidae, or round-headed borers. Object and procedure same as for preceding project, except that this is a special project.

Status.—Work begun in 1904 and conducted from East Falls Church, Va. (field station); field of operations, United States.

Results.—The results of a special study of this class of bark and wood borers have shown that they are far more destructive than was heretofore supposed. Special progress has been made in the acquiring of new information on the seasonal history and habits of a large number of species and in the development of remedies. A result of exceptional value and importance is the successful experiments with poisoned kerosene emulsion and other contact insecticides against the locust borer in some large plantations. This resulted in the killing of from 90 to 95 per cent of the young larvae before they entered the wood, at a comparatively small cost, and showed that plantations of black locust which have heretofore failed on account of the borer can now be successfully maintained, and thus add greatly to the supply of one of our most important wood products.

The oak shade and forest trees of the Southern States have suffered severely from the attack of the Romaleum oak borer in the main trunks and the Prionus root borer in the roots. The special investigations and experiments carried on have resulted in the determination of many new facts relating to the insects and methods of protecting the trees against their destructive work.

Assigned to F. C. Craighead.

272. **Economic study of beneficial forest insects.** To determine the character and extent of beneficial influences of parasitic and predatory insects, their histories and natural enemies, and methods of propagating and encouraging their beneficial work; and to secure the importation of foreign species and the artificial dissemination of native species.

Procedure.—Same as for preceding, except that this is a general project.

Status.—Work begun in 1903, and carried on at Lyme, Conn., and East Falls Church, Va. (field stations); field of work, United States.

Results.—Many new facts have been determined regarding the principal parasitic and predacious insects which are the natural enemies of injurious insects, and this information has been of special importance in connection with the practical application of artificial methods of control. Special progress has been made in the new feature taken up last year on the investigation of gall insects, *viz.*, to determine the relative value of American galls for dyes and inks as compared with the Aleppo galls of China. The Bureau of Chemistry is assisting in this work by analyzing the various galls submitted by the specialists assigned to the project.

Assigned to A. D. Hopkins, A. B. Champlain, S. A. Rohwer, and Adam Boving.

273. **Bark lice of the genus Chermes.** The determination of systematic and bionomic facts relating to the species of Chermes which infest the bark of coniferous and other forest trees, with special reference to the species involved, their life history and habits, and methods of combating them.

Procedure.—Same as preceding project.

Status.—Begun in 1908.

Results.—It has been found that this class of insects, each species of which lives alternatively on two different species of trees, making galls on the twigs of spruce and infesting the twigs and bark of pine, is of special economic importance. It has been discovered that if nursery and ornamental trees are sprayed with kerosene emulsion at the time new growth starts on the twigs it will protect the trees from damage by this class of insects. Special progress has been made in this line of investigation, especially on the species affecting western conifers, including the discovery of many new facts. Experiments with kerosene emulsion and nicotine sulphate on spruce and pine at Colorado Springs, Colo., showed that both of these contact sprays were effective remedies against the bark and gall lice.

Assigned to A. D Hopkins, J. H. Pollock, and Jacob Kotinsky.

274. **Insect-control instructions and demonstrations in the National Parks and National Forests.** To give instructions on the essential practical details and to conduct demonstration projects on the control of Dendroctonus beetles in national parks and national forests in accordance with principles and methods recommended by the Bureau of Entomology.

Procedure.—This is a special demonstration and instruction project, in which the Department of the Interior and the Forest Service detail rangers to the Bureau of Entomology to receive instructions from an entomological ranger of this bureau, who has been trained as an expert on the practical details of cruising and locating infested timber and in the application of measures advised by the leader of this project. The instructions relate to (*a*) methods of cruising to locate the infested timber requiring treatment, (*b*) the essential practical details of conducting the work of control and protection against Dendroctonus beetles, (*c*) the inspection of areas in which control work has been done, (*d*) the location of areas requiring treatment, (*e*) estimating the character and extent of insect-killed or infested timber, and (*f*) advice on such other matters pertaining to the practice of forest entomology as may be deemed necessary. All entomological matters except the minor questions that can be handled by the insect-control expert will be referred by him either to a local entomological expert of the Branch of Forest Insects, Bureau of Entomology, or to the chief of the branch at Washington for advice or recommendations. The Bureau pays the salaries of the entomological rangers. The Department of the Interior and the Forest Service pay their traveling and field expenses and also the salaries and expenses of their rangers assigned to the work and the expenses of all cruising and control operations. When the park and forest rangers are sufficiently trained and qualified, they are designated as insect-control rangers and assigned to a national park or national forest to work under the immediate supervision of the park or forest supervisor or superintendent.

The attention to this subject in 1918–19 will be mainly in the line of recommendations and instructions in the Sequoia National Park and Sequoia National Forest.

Status.—Begun in 1913 and conducted in cooperation with the National Park Service and the Forest Service.

Results.—This work has resulted in verifying and demonstrating the practicability and efficiency of the percentage principle of control. The Yosemite Valley is now practically free from damage. Special interest has been aroused among the principal private owners of timber in California, who have requested a survey of the State to ascertain the character and extent of the depredations by Dendroctonus beetles and to develop methods of control. A special informal arrangement between the private owners, the Bureau of Entomology, the Forest Service, and the National Park Service of the Interior Department has also been effected, whereby a representative of the Bureau of Entomology has been charged with the general supervision of the work, the pro rata field expenses involved to be borne by the directly interested private owners and public service.

Assigned to A. D. Hopkins and J. M. Miller.

275. **Investigation of insects affecting shade trees and hardy shrubs.** To determine (*a*) the general character and extent of damage by insects to the trees and shrubs of public and private grounds, including municipal parks, streets, cemeteries, country roads, private parks, national cemeteries, etc., (*b*) additional facts on the seasonal histories and habits of the insects involved, and (*c*) additional facts on practical methods of prevention and control; to conduct experiments, and finally to give

advice through correspondence, publications, and otherwise, on the principles and methods of control to meet the requirements of specific insects and local conditions.

Procedure.—This is a general project to which members of the regular field and laboratory force give more or less attention, collecting material and studying and identifying insects. The small allotment of funds available for this work renders the field of operations so limited that very little can be accomplished except along restricted lines of investigation. Some informal cooperation with municipalities, Federal and State officials, and owners of private parks and grounds will be invited, looking to their adoption of the most economical and effective methods of prevention and control, the conduct of experiments with new methods, and the verification of results in practice.

Status.—The work was begun in 1915. Much assistance has been rendered, by way of advice through correspondence, in connection with shade-tree problems. The work of the field laboratory at Los Gatos, Calif., has been directed to the investigation of local problems, one receiving special attention being a study of the defoliation of oak shade trees by caterpillars. An aphis on walnut shade trees at Los Gatos, Calif., has proved troublesome in that its attacks result in the pavements and streets becoming slippery by reason of the quantities of honeydew exuded. Spraying the trees with nicotine sulphate proved to be a successful means of eliminating the trouble.

Results.—As a result of extensive instruction and demonstration work on Long Island, N. Y., during the past two years, a serious menace to the hickory and oak shade and forest trees of the island has been effectively removed through the activity of property owners in carrying out the recommended method of cutting and utilizing or otherwise disposing, during the fall, winter, and early spring, of a majority of the trees that died the preceding summer.

Assigned to A. D. Hopkins, H. E. Burke, and Jacob Kotinsky.

LABORATORY INVESTIGATIONS

The work under this group has special reference to original research on the more technical features of the science of forest entomology and has yielded some of the most important results in the line of essential and fundamental information on which to base economic research and practice. For each family of insects studied. The object is to (*a*) determine, classify, and describe the genera, species, and stages of development which are new to science; (*b*) revise and bring up to date the systematic knowledge of all North American species; (*c*) investigate problems relating to anatomy, taxonomy, terminology, and nomenclature; (*d*) determine seasonal histories, food, and breeding habits, geographical distribution, and such other information of a technical nature about the species as is essential to the best success in the investigation and practical treatment of economic problems.

Procedure.—These are special projects, in which specimens of all stages of the insects and their work are collected by the leaders and members of the force in connection with their regular field duties from all parts of the United States or are received by exchange or for identification from all parts of the world. These specimens are labeled, classified, and preserved in a separate collection in the National Museum with the collection of forest insects under the custodianship of the leader. Such time as can be spared from the regular administrative duties is devoted to a systematic study of the material and the literature on the subject and to the preparation of manuscript for permanent record and publication.

276. **Forest and other Scolytidae.** Studies begun in 1902 and carried on from Washington, D. C. The results of the systematic work on this group of insects have shown that previous to the leader's work on this group nothing whatever had been known of a large number of the most destructive insect enemies of North American forest trees. The information acquired has made it possible to study their exact economic relations to the trees and to discover practical methods of control and prevention. The value of the results of this work alone may be estimated in tens of millions of dollars toward the practical conservation of the forest resources of the United States. The collections are the largest in the world, and specimens are sent here from many other countries for authentic identification.

Assigned to A. D. Hopkins.

277. **Forest and other Buprestid larvae.** Studies begun in 1904 and carried on at Los Gatos, Calif. (field laboratory); field of operations, United States. Heretofore practically nothing was known of the systematic characters by which the larvae of various species of this class of insects could be identified, and without this knowledge very little could be accomplished in the study of seasonal histories and habits, and practically nothing could be done toward the discovery of effective methods of control. Special progress has been made in this work in the discovery of new facts of economic importance.

Assigned to H. E. Burke.

278. **Forest and other Cerambycid larvae.** Studies begun in 1904 and carried on from Washington, D. C. Exceptional progress has been made in the investigation of these larvae. While they are of great economic importance, very little was known about them a few years ago. Now more than 250 species have been identified and a fund of information acquired of great scientific and economic value. Special progress has been made in the preparation of important manuscript for publication.

Assigned to F. C. Craighead.

Investigations are also being conducted on forest Hymenoptera, Lepidoptera, Coleoptera, Diptera, and forest and other Isoptera and Coleopterous larvae.

RESEARCH ORGANIZATIONS WITHIN THE STATES

State Departments, Universities, and Private Agencies

NEW ENGLAND STATES

NEW HAMPSHIRE

NEW HAMPSHIRE STATE FORESTRY DEPARTMENT

J. H. Foster, Acting State Forester. Concord, N. H.

279. **Fire protection.** (*a*) Brush disposal with reference to cost and efficiency of different methods and effect on reproduction. (*b*) Fire lines—cost of establishment and cost and efficiency of maintenance by different methods.

Information to be obtained during the coming fall and winter.

Assigned to J. H. Foster.

280. **Planting.** Relative cost and efficiency of spade versus mattock for different types of soil cover.

Information to be obtained during the coming spring and summer.

Assigned to J. H. Foster.

281. **Statistical and economic survey of forest resources of New Hampshire.**

Under way.

Work expected to continue one or two years.

Assigned to J. H. Foster.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

K. W. Woodward, Forester, New Hampshire College, Durham

282. **Thinning.** Thinning of immature stands of white pine and hardwoods to determine the best methods and financial returns from such thinnings.

Begun by J. H. Foster in 1913. Twenty-six plots have been established in the vicinity of Durham.

The sample plots are measured annually and a preliminary statement of results is now in preparation. Periodic reports are to be made every 10 years. It is planned to extend the experiment to include the thinning of other native species such as spruce.

Assigned to K. W. Woodward.

283. **Growth of exotics.** Rate of growth of various exotics, such as Scotch pine, Douglas fir, European larch, and Norway spruce.

Plantations of these species were started by J. H. Foster in 1913.

Plots remeasured annually. Periodic reports to be published every 10 years. It is planned to extend the experiment to include the trying out of all tree species suitable to New Hampshire climatic conditions.

Assigned to K. W. Woodward.

VERMONT

UNIVERSITY OF VERMONT

Department of Botany, Prof. G. P. Burns, Burlington

284. **Forest reproduction.** A study of natural reforestation in Vermont.

Begun in cooperation with Vermont State Forester A. F. Hawes in 1914, on plans prepared by Hawes. A sample plot 200 feet square was established, with a control plot of equal size, in each of five types of forest. These plots were given different degrees of thinning for the combined purpose of reproduction and increment study (the latter treated in the following project). In each plot two or more sub-plots, each 10 feet square, were staked out and an exact survey including maps was made of each. A permanent record was made of every plant growing on each sub-plot.

These surveys are repeated every year and new maps and records made. A study of these maps and records shows the changes which are taking place.

Assigned to Professor Burns.

285. Diameter growth in forest.

Begun in 1914 in cooperation with the State Forester, on plans prepared by Mr. Hawes. The plots above described were accurately mapped before thinning, the number, size, and location of the trees to be removed being recorded. Individual trees left were numbered and measured.

Comparative records of diameter growth in the thinned and unthinned plots are being kept.

Assigned to Prof. Burns.

286. Eccentric growth. A study of the factors causing eccentric growth, especially the so-called glassy or "red wood" in pine and spruce.

Greenhouse and field experiments are under way to determine the influence of the wind, position, trimming, etc., on diameter growth. An anatomical study and mechanical tests are being made on the wood developed under the various experimental conditions.

Assigned to Prof. Burns.

287. Tolerance of New England forest trees. The immediate problems in hand are:

(*a*) To determine the minimum light intensity required by each species of our forest trees for the production of a slight surplus of organic matter. The source of light used in this work is a National Mazda C lamp equipped with a Nela screen. Two screens are in use, one giving direct and the other diffused light.

(*b*) To determine the effect of different light rays on the development of forest trees. In this work the colored glass produced for MacDougal at the Tucson Desert Laboratory is used. The glass is set in wooden frames each holding 16 panes, 80 panes for each experimental chamber. The four-sided frames are made with 8-inch bases to give greater height and reduce expense. The plants used are pot cultures.

(*c*) To determine the effect of reduced white light on development of seedlings under nursery conditions. The plants are shaded with cheesecloth, using from one to six thicknesses. Special effort is being made to maintain similar moisture conditions in the groups of plants to be compared. Check experiments are also under way in the greenhouses.

(*d*) To determine the water requirement of the more important forest trees and its relation especially to growth in height and diameter. Pot cultures are used in the work.

(*e*) To study the effect of environmental factors on the development of trees. A series of records of the more important factors of the habitats have been kept for several years and the attempt is being made to determine the effect of these factors which together made up the site with the development of the trees grown there. Stations have been established at the State Nursery, in white pine forests near Burlington, in region near the timber line on Mt. Mansfield and on the summit of the mountain above timber line.

Assigned to Prof. Burns.

MASSACHUSETTS

MASSACHUSETTS STATE FORESTER

William A. L. Bageley, State House, Boston

288. Forest survey of State. To determine by strip reconnaissance the amount of forest land by types and size classes in each town, fire damage, insect damage, etc.

Two counties (Worcester and Plymouth) completed and results published: "Forests of Worcester County," by H. O. Cook, and "Forests of Plymouth County," by James Morris.

Another county to be surveyed in 1920.

289. **Cordwood measurements.** The amount of cubical space occupied by wood cut in short lengths and restacked or loose piled.

Completed and results ready for publication under title of "Measurement of Fuel Wood," by H. O. Cook.

290. **Planting.** Experimental plantation on Cape Cod with plots of white, red, Scotch, and Austrian pines, Norway spruce, Douglas fir, and arborvitae, to determine availability of species in poor soil and strong wind exposure.

Plantation completed.

Similar sample plantations to be made in other sections.

291. **Oak volume table.** Preparation of an oak volume table (bd. ft.) for second growth in Massachusetts.

Field work about one-half completed.

292. **Pine weevil control.** Systematic removal each year of weevil-infested shoots in an isolated plantation to see if insect can be controlled.

Work done for two successive years.

To be continued each year as long as necessary.

HARVARD UNIVERSITY.

Bussey Institution for Research in Applied Biology, Forest Hills, Boston, Mass.
Dr. W. M. Wheeler, Dean
R. T. Fisher, Professor of Forestry and Director of Harvard Forest, Petersham, Mass.
I. W. Bailey, Professor of Plant Anatomy, Forest Hills, Boston

Studies at Bussey Institution for Research in Applied Biology

293. **Dendrology.** Manual of the forest trees of China.

Intended primarily for foresters. To be published in English and Chinese.

Assigned to W. Y. Chun, under the direction of Prof. J. G. Jack. Mr. Chun has been voted a Sheldon Traveling Fellowship for 1919–20 to enable him to collect material and data on the forests of China.

294. **Forest entomology.** Oak galls and the insects which produce them.

Under way. To be conducted in the South, Southwest, and California.

Assigned to A. C. Kinsey, under the direction of Prof. W. M. Wheeler. Mr. Kinsey has been voted a Sheldon Traveling Fellowship for 1919–20 for the purpose of collecting and making field observations.

295. **Economic botany (forest products).** Catalog of principal botanical raw products of the world.

A large working collection of economic products is rapidly being brought together. Endeavor is being made to correlate scientific and common names. Catalog to include forest products of both temperate and tropical regions.

Continuing.

Assigned to Prof. Oakes Ames and assistants.

296. Wood technology. Studies of:

(*a*) Cambium of arborescent *Conifers* and *Dicotyledons;* cytological, histological, and physiological.

(*b*) "Fiber" of coniferous and broad-leaved trees.

(*c*) Effects of light, gravity compression, and tension upon the structure of stems and branches.

(*d*) Variations in structure of wood and the principal factors which produce them.

(*e*) Effects of the structure of wood upon its technical properties.

(*f*) Identification of herbarium material and wood of tropical trees.

Herbarium material of tropical trees collected by Prof. Whitford, Mr. Curran, and others is identified by members of the staff of Gray Herbarium. Wood sections accompanying these sheets are sectioned and filed under direction of Prof. Bailey for subsequent use in the construction of a key to the principal families and genera of woods.

The studies in wood technology are continuing.

Projects *a-e* assigned to Prof. I. W. Bailey.

Project *f* assigned to Gray Herbarium and I. W. Bailey, in cooperation with Yale Forest School.

Studies Conducted at Harvard Forest, Petersham, Mass.

297. Reproduction cuttings. To test the efficacy of various cutting methods for the reproduction of white pine and chief associated species.

Annual cutting areas under observation and record since 1909. Systems employed: modification of clear cutting and shelter-wood methods. Paper on the reproduction of white pine in preparation.

Continuing.

Assigned to Prof. Fisher.

298. Improvement cuttings. Experiments to determine method, costs, and possibilities of improving the composition and yield of mixed stands by early weeding.

Areas under treatment, including permanent sample plots, since 1912. Paper on "Yield of Volunteer Second Growth," by R. T. Fisher, published in Journal of Forestry, May, 1918.

Continuing.

Assigned to Prof. Fisher.

299. Recovery from suppression. Relation of recovery of suppressed trees to age, site, and extent of release.

Sample plots under observation.

Continuing.

Assigned to Prof. Fisher.

300. Thinning. Permanent sample plot in pure even-aged white pine to accumulate data on the effect of periodic thinning upon yield, etc.

Plot established in 1912. Thinning and records made every five years.

Continuing.

Assigned to Prof. Fisher.

301. Plantations.

Permanent sample plot in plantation of white pine to follow annual progress in height growth, establishment of cover, natural pruning, etc.

Planted in 1909. Records begun in 1913.
Continuing.
Assigned to Prof. Fisher.

302. **Plots in plantation of white pine to determine effect of planting distance upon yield.** Distances used are 3, 4, 5, and 6 feet.
Established in 1916.
Continuing.
Assigned to Prof. Fisher.

303. **Plantations for test of species under various site conditions, in competition with natural reproduction on open and cut-over land; and for test of underplanting.** Comparative value of certain exotic species in reforestation.

Approximately 80 acres planted from 1909 to 1919. Species used: white, Norway, Scotch, and western yellow pines, Norway spruce, European and Japanese larch, and Douglas fir.
Continuing.
Assigned to Prof. Fisher.

304. **Commercial planting: a study of the silvicultural lessons of forest planting in Massachusetts.**

Examination of existing plantations in light of all available data as to establishment, history, etc.
To be completed in summer of 1920.
Assigned to A. H. Richardson, research student, Department of Forestry.

305. **Lumbering.** Collection of cost data on operations in portable mill logging, sawing, etc.
Records filed from classified time sheets. Publication planned.
Continuing.
Assigned to Prof. Fisher.

306. **Measurements.**
Mill tally volume tables for second-growth chestnut.
Completed but not published.
Mill tally log scale for white pine.
Completed but not published.

307. **Growth study.** A yield table for second-growth hardwoods in central New England.
Fifty sample plots measured and computations now in progress.
Assigned to J. N. Spaeth research student, Department of Forestry.

Studies conducted at both the Bussey Institution and the Harvard Forest

308. **Forest entomology.** Studies of *Hylobius pales* in relation to injuries to conifers.
Field, laboratory, and library investigations in progress.
To be completed in autumn of 1920.
Assigned to H. B. Pierson, under direction of Professor C. T. Brues, and R. T. Fisher.

MASSACHUSETTS AGRICULTURAL COLLEGE

Department of Forestry. William D. Clark, Professor of Forestry, Amherst

309. **Improvement cuttings on the Mt. Toby State Demonstration Forest of 754 acres looking toward the development of a more productive forest.**

Removal of blighted chestnut begun October, 1916. To date 750 cords of wood, 3496 railroad cross-ties, and 28,586 linear feet of telephone poles have been removed.

Cutting proceeding, looking toward the entire elimination of chestnut from the forest and the substitution of white and red pine by planting and natural seeding.

Assigned to W. D. Clark, Professor of Forestry and head of the Department of Forestry at Massachusetts Agricultural College in charge.

CONNECTICUT

YALE UNIVERSITY

Yale Forest School, J. W. Toumey, Dean, New Haven

Silvicultural Research

310. Yield of coniferous plantations in southern New England; particularly of white and red pines in pure and mixed stands, but including other conifers as opportunity offers.

Twenty-seven permanent sample plots, from 1/4 to 1 acre in size, were established in young stands in 1917 and 1918, and the essential measurements taken. The individual trees will not be numbered, this refinement being unnecessary to accomplish the purpose of the experiment. Four qualities of site—1, 2, and 3 (well drained) and 1*b* (bottomland); and six species—white, red, Scotch, and western yellow pines, Norway spruce, and European larch—are represented. The plots are located as follows: New Haven County, Conn., plots 4–6 and 11–29, inclusive; Union, Tolland Co., Conn., plots 101, 102, 109, 110; Rainbow, Hartford Co., Conn., plot 100.

Ten or fifteen new plots per year will be established in 1919 and subsequent years until the various sites and the range of coniferous species suitable for planting in southern New England have been covered. In 1922 remeasurement of the plots first established will be started. Time for completion, 60 years.

Assigned to Prof. R. C. Hawley.

311. Thinning: results on bottomland and swamp sites (disappearance of chestnut makes thinning experiments on upland of small consequence in southern Connecticut).

One set of 4 plots aggregating seven-eights acre was established and measured in 1916–17 at Maltby. Two other series at Saltonstall and Wapowaug reservoir are approximately one-third complete. Location and plot numbers: New Haven Co., Conn., plots 1, 2, 3, 8, and 9. Permanent plots, variously thinned, with check plots; individual trees numbered and measured.

Only the three sets of plots are planned. They will be established within two years. Time for completion, 20 to 30 years.

Assigned to Prof. R. C. Hawley.

312. Thinning: results on upland sites.

Five plots (including check plot) aggregating 0.45 acre were established at Ansonia, New Haven Co., Conn., in 1906, and remeasured in 1911 and 1916. Individual trees numbered and measured.

To be remeasured in 1921. Time for completion, 30 years.

Assigned to Prof. R. C. Hawley.

313. Thinning: results in naturally reproduced stands of white pine.

Three sets of plots, with check plots, established as follows: One set (plots 601–604, inclusive, aggregating 1 1/4, acre) in 1905, at Keene, N. H., in 35–40-year-old pine; two sets (plots 104–108), inclusive, aggregating 1 1/8 acres) in 1916, on the Geo. Myers estate, Union, Conn., in 25 and 60-year-old pine. Individual trees numbered and measured; thinnings have been made. In one series at Union, Conn., selected trees were pruned up 17 feet.

The established plots to be thinned and remeasured frequently. Time for completion, 30 years.

Assigned to Prof. R. C. Hawley.

314. Thinning: results in chestnut and oak sprout groups while in sapling stage.

Three plots (Nos. 398, 399, and 400) of one-tenth acre each were established at Ansonia, Conn., in 1906. Plot 398 left intact, the others thinned. Important sprout groups indicated on crown cover diagrams. All reproduction tallied. Age of sprouts at date of establishment, 4 years. Trees measured and numbered in 1916.

To be remeasured in 1921. Time for completion, 30 years.

Assigned to Prof. R. C. Hawley.

315. Reproduction and increased growth in hardwood stands after heavy thinnings.

Seven main plots and 63 reproduction plots established at Maltby Park, New Haven, Conn., in 1906, and remeasured in 1911 and 1916. Individual trees numbered and measured, reproduction tallied. Main plots numbered 321–327 and reproduction plots 328–390, inclusive.

To be remeasured at 5-year intervals. Time for completion, 20 to 30 years.

Assigned to Prof. R. C. Hawley.

316. Pruning: effect of early pruning of live limbs upon the height growth of planted white pine, with the purpose of developing the best methods of pruning.

A permanent plot (plot No. 11) 1 acre in size was established in New Haven Co., Conn., 1/4 being left unpruned and the remainder to receive the following treatment: selected trees should be pruned every three or four years, removing several whorls of live branches at each pruning, until a 17-foot clear log is produced. In March, 1917, 192 of the best dominant trees spaced 12 to 20 feet apart were pruned. All but the last three or in some cases the last two whorls of live branches were removed. This was too heavy a pruning as height measurements taken in the winter of 1919 indicate.

Trees.	Number.	Annual height growth in feet. 1915.	1916.	1917.	1918.
Pruned	112	1.87	2.13	1.45	1.43
Unpruned	169	1.53	1.75	1.95	2.13

At least two more prunings will be needed to secure a 17-foot length. Another plot will be established to determine how heavy a first pruning may be made and not injuriously affect the height growth. Time of completion, 10 to 15 years.

Assigned to Prof. R. C. Hawley.

317. Reproduction of white pine stands under the shelterwood system.

Three main sample plots aggregating 1.05 acres and 11 reproduction plots were established at Keene, N. H., in 1905 and remeasured in 1909 and 1915. Plots numbered 605–610 and 612–619, inclusive. One main plot (605), in stand which had been heavily thinned in 1904, was cut clean in winter of 1912–13. Another (612) was given a reproduction cutting in the winter of 1913–14. The third (614) is yet untreated. Age, all plots, in 1905, 50 to 55 years.

To be remeasured in 1920. Time for completion, 20 years.

Assigned to Prof. R. C. Hawley.

318. Natural reproduction of white pine from adjoining seed woods.

Plot (No. 611) established at Keene, N. H., in 1905 and remeasured in 1909 and 1915.

To be remeasured in 1920. Time for completion, 11 years.

Assigned to Prof. R. C. Hawley.

319. Diameter growth of individual Liriodendron tulipifera trees.

Three individual trees (plot No. 316, Maltby Lake tract, New Haven) numbered and measured in 1904 and remeasured in 1909 and 1919.

Time for completion, 20 years.

Assigned to Prof. R. C. Hawley.

320. Early development of mixed hardwood sprout stands.

Four plots (Nos. 317–320, inclusive) established at Maltby Lakes, New Haven, in 1904, and remeasured in 1909, 1916, and 1919. Plots each 1 chain square.

Time for completion, 20 years.

Assigned to Prof. R. C. Hawley.

321. Production in balsam swamps after cutting.

To study amount and cause of loss of standing trees and progress of reproduction.

A 2-acre permanent plot (Nehasane Park Association, No. 201) was established in Herkimer Co., N. Y., in 1916, and measured in 1917, 1918, and 1919. Individual trees numbered and measured.

To be remeasured at frequent intervals noting particularly amount and cause of loss of standing trees and progress of reproduction.

Assigned to Prof. R. C. Hawley.

322. Investigation of gray birch in its effect upon the regeneration of white pine.

This investigation develops a method for determining the average chemical light intensity under stands of different degrees of density. The conclusions are that the slow growth of white pine under dense stands of gray birch is primarily due to root competition and not to diminished light as heretofore believed.

Assigned to Prof. J. W. Toumey.

323. Tolerance.

A project is under way having for its purpose a better understanding of tolerance with studies based upon instrumentation.

Assigned to Prof. J. W. Toumey.

324. Silvical studies.

Studies are projected having for their purpose the investigation of climatic and soil factors in relation to pure, even-aged stands on a number of our permanent sample plots.

Assigned to Prof. J. W. Toumey.

Research in Lumbering

325. Wholesale lumber prices during the war period, 1913–1918.

Results published under the title of "Prices of Lumber," by R. C. Bryant, Industrial Examiner, Forest Service. War Industries Board Price Bulletin No. 43, 1919. Published in cooperation with the Forest Service.

Assigned to Prof. R. C. Bryant.

Technological Research

326. Mahogany and some of its substitutes.

This research has for its object the development of a descriptive key based on gross and lens characters. See contributions from the Yale School of Forestry, No. 11.

Assigned to Prof. S. J. Record.

327. Stored or tier-like structures of certain dicotyledonous woods.

See contributions from the Yale School of Forestry No. IV.

Assigned to Prof. S. J. Record.

328. The woods of the Zygophyllaceae.

Although one paper on this subject has already been published in Scientific American Supplement, work is being continued with the expectation of a comprehensive paper in the autumn of 1919.

Assigned to Prof. S. J. Record.

329. Woods of the Leguminosae.

Research on the woods of this family, particularly species from tropical regions, have been under way for some time.

Assigned to Prof. S. J. Record.

330. Studies on various groups of tropical American woods.

Results will probably appear in connection with a proposed book on the forests of tropical America.

Assigned to Prof. S. J. Record.

Research in Tropical Forestry

331. Tropical forests and the war.

See "Tropical Forests and the War," by H. N. Whitford, Journal of Forestry, May, 1918; Vol. 16, No. 5, pp. 507–522.

Assigned to Prof. W. N. Whitford.

332. The structure and value of the Parana pine forests of Brazil.

See contributions from the Yale School of Forestry, No. 3.

Assigned to Prof. W. N. Whitford.

333. Tropical forest products.

See Encyclopedia Americana.

Assigned to Prof. W. N. Whitford.

334. The forestry report of the Guatamala-Honduras Economic Survey Expedition.

This report has been prepared and will appear as a publication later on.

Assigned to Prof. W. N. Whitford.

335. Forests of South America.

Progress has been made in assembling the information collected for this publication. A preliminary forest map of South America has been completed which shows the forest regions of the continent and divides these into possible commercial areas.

Assigned to Prof. W. N. Whitford.

Miscellaneous Research

336. Increment and losses over the entire area of the western yellow pine type, Coconino and Tusayan National Forests, with methods of determining these factors, the development of a method by which the area occupied by different age classes can be practically determined for a western yellow pine forest of mixed age classes, the factor of density of stocking or empirical (actual) yield may be determined by using a "normal" yield table, a stand table and total estimates for the type, the future yield of the forest can be computed for the next 200 or 300 years.

Method completed. Application to Coconino and Tusayan National Forests completed September, 1919. See Working Plan for Coconino and Tusayan National Forests (MSS.) Forest Service, Albuquerque, New Mexico.

Assigned to Prof. H. H. Chapman.

337. Damage to western yellow pine reproduction by sheep grazing and its effect upon forest management.

Final conclusions practically completed by study planned and executed in fall of 1919 on Tusayan and Coconino National Forests, Arizona. See reports by Westvelt and Kimball, and studies by Pearson.

Assigned to Prof. H. H. Chapman.

338. The forests of British Columbia.

See "The Forests of British Columbia," by H. N. Whitford and R. D. Craig. Commission of Conservation, Ottawa, Canada, 409 pages, 1919.

Assigned to Prof. W. N. Whitford.

Osborn Botanical Laboratory, Prof. George E. Nichols, New Haven

339. Ecological survey of the vegetation of Connecticut.

Begun in 1910 and carried on intermittently since that time. Publications: "The Vegetation of Connecticut" (series), as follows:

I. Phytogeographical aspects. Torreya 13, 89–112, f. 1–6, 1913.

II. Virgin forests. Torreya 13, 199–215, f. 1–5, 1913.

III. Plant societies on uplands. Torreya 14, 167–194, f, 1–8, 1914.

IV. Plant societies in lowlands. Bull. Torrey Club 42, 169–217, 1915.

V. Plant societies along rivers and streams. Bull. Torrey Club 43, 235–264, f. 1–11, 1916.

VI. The plant associations of eroding areas along the seacoast. Bull. Torrey Club 47 (in the press), 1920.

VII. The plant associations of depositing areas along the seacoast. Bull. Torrey Club 47 (in the press), 1920.

Also the following: Summer evaporation intensity as a determining factor in the distribution of vegetation in Connecticut. Bot. Gaz. 56: 143–152, 1913.

A bulletin on "The Vegetation of Connecticut" to be prepared as result of field work ending this summer.

Assigned to Prof. G. E. Nichols, under auspices of Connecticut State Geological and Nat. Survey.

340. Ecological survey of the Penobscot Bay region, Maine.
This is a continuation of work begun in 1913 and partially treated in the following publication: "The vascular flora of the eastern Penobscot Bay region, Maine," by Albert F. Hill, Proc. Portland Soc. Nat. Hist. 3: 199–304, f. 1–6, 1919.

Additional field work in the summer of 1920 is contemplated by Mr. Hill.

Assigned to Albert F. Hill.

MIDDLE ATLANTIC STATES

NEW YORK

CORNELL UNIVERSITY

New York State College of Agriculture
Department of Forestry, R. S. Hosmer, Professor of Forestry, Ithaca

341. Volume, growth, and yield studies. To collect and present growth data in such form that the probable yield can be predicted for given species, on given sites, for given times in the future, and under a given system of management.

Work begun May 1, 1919.

To begin with red pine and red spruce in New York State. Object of preliminary studies, to improve present methods of measuring growth. Next, the influence of site factors on growth will be studied. Study to be of individual trees and stands, and by both temporary and permanent sample plots.

Assigned to John Bentley, Jr., Professor of Forest Engineering, and B. A. Chandler, Assistant Professor of Forest Utilization.

SYRACUSE UNIVERSITY

New York State College of Forestry, F. F. Moon, Acting Dean, Syracuse

Silviculture

342. Knot zones and spiral in Adirondack red spruce. To determine amount suitable for airplane stock and influence of growth in virgin forest on cleaning of bole and direction of fiber.

Work carried on two months in summer of 1918. Results published in "Knot Zones and Spiral in Adirondack Red Spruce," by Edward F. McCarthy and Raymond J. Hoyle, in Journal of Forestry, Vol. 16, No. 7, Nov., 1918, pp. 777–791.

Study of spiral will be extended to second growth as opportunity offers.

Assigned to E. F. McCarthy and R. J. Hoyle.

343. Reproduction on cut-over lands in the Adirondacks. To determine relation of various conditions of cutting on reproduction of pulp species on the several natural types of forest.

Work begun in 1917 (July) using strip method followed by a square rod sample plot (3 to the acre) for reproduction count. Height increment studies made by measurement of nodes and diameter increment on diameter limit cuttings. Published: "Production of Pulp on Balsam Lands," Paper, Oct. 23, 1918. Data on accelerated growth and reproduction in hardwood type read before New York Section of Society of American Foresters and sent to the Journal of Forestry for publication.

The result of this study has directed the investigators to the need of more detailed information concerning the hardwoods which is planned for the coming year.

Assigned to E. F. McCarthy and R. J. Hoyle.

344. **Site studies of planted species.** To determine height and diameter growth and pruning, with purpose of standardization of site and determination of values in site factors.

Work begun spring of 1918; two permanent sample plots established one in 6′ x 6′ Scotch pine, the other in 6′ x 6′ Norway pine. One sample plot established in November, 1918, in 6′ x 6′ western yellow pine. Height increment and pruning studied by a measurement of nodes.

Diameter increment to be obtained by measurement of the permanent plots at 5-year intervals. Present data to be correlated with those collected later. Work to be extended and new plots established as rapidly as possible.

Assigned to H. C. Belyea.

345. **Studies of forest conversion.**

(*a*) Yellow birch in the Adirondack and Catskill regions of New York State. To determine relation of this species to production of softwood in northern forest of New York; improved methods of utilization; creation of market for future second growth; pathological factors controlling species; relation to forest animals; importance relative to other hardwood species.

Reproduction data already collected in 1917. Summer's work with field party, 1919.

Following the completion of the study of yellow birch work will be extended to other hardwood species as the necessity for it is made evident by the birch study; conversion plantations will be made under typical conditions for each type.

Assigned to heads of Departments of N. Y. State College of Forestry under direction of College Committee on Research.

Forest Botany and Pathology

346. **White pine blister rust.** Field investigations to determine the conditions which influence or control the spread of the disease, *viz.*, dispersal, viability, possibility of overwintering upon Ribes, etc.

Work carried on during the field season of 1918 in Lewis, N. Y. The investigations were continued in 1919.

Assigned to Dr. Leigh H. Pennington.

347. **Pathology of yellow birch in New York State.** This is a part of the cooperative study of yellow birch of the College.

Experimental work was begun in the summer of 1916.

Assigned to Dr. L. H. Pennington and Dr. Alfred H. W. Povah.

348. **Fungi of the seed and seedling of Pinus strobus.** A study to determine the mycological flora with a view to obtaining data on the species concerned with mycorhiza, damping-off, etc.

Preliminary studies are under way.

This study will be continued this summer.

Assigned to Dr. A. H. W. Povah.

349. **Stereums associated with timber decay.** To determine something of the nature, life history, and physiology of stereums.

Work being carried on as subject for thesis.

Assigned to Mr. Don M. Benedict.

350. **A survey of the fungous flora of the forests of the State.** To determine the frequency and distribution of the fungi which cause disease, timber decay, or form part of the forest floor in New York State Forests.

Data have been collected for the past several years.

Considerable time will be required for this project.

Assigned to all members of the Dept. of Forest Botany and Pathology.

Dendrology and Wood Technology

351. **Trees of New York State, indigenous and naturalized.** A bulletin to contain about 130 plates drawn directly from nature, with legend accompanying each plate, together with tabulated information covering each species. The bulletin will also contain a certain amount of descriptive botany, keys to families, genera and species, a glossary, etc.

Plates complete. Manuscript in course of preparation. Should be ready for the press May, 1920.

Assigned to H. P. Brown.

352. **An anatomical study of Betula lutea.** A complete anatomical survey of yellow birch including seed, seedling, bark, wood, leaves, seasonal growth, fiber lengths, etc., together with phenological observations.

Work was started in the summer of 1919.

To be continued this summer.

Assigned to H. P. Brown, Mr. Cuno, and others.

353. **Microscopical atlas of the commercial woods of the United States.** The work will include three plane drawings of the wood of the more important commercial species with minute descriptions and keys for identification.

The work was started in September 1919. Part of the plates are complete.

Assigned to C. C. Forsaith.

354. **Fiber yields from American woods.** (*a*) The bearing of the wood ray on pulp yield. A correlation of the fluctuation in pulp yield between species with the volume of the wood rays. (*b*) Other problems pending.

Assigned to Mr. DeSmidt and H. P. Brown.

355. **Microscopic atlas of commercial Philippine woods.** An anatomical and taxonomic study of Philippine woods including photo micrographic and keys for the determination of species. I. Philippine Dipterocarpaceae.

The work was started in January, 1920.

Assigned to L. J. Reyes and H. P. Brown.

356. **Microscopic atlas of commercial Chilean woods.** An anatomical and taxonomic study, including photo micrographs and keys for the determination of species.

Work was started in January, 1920.

Assigned to Lawrence Lee.

357. **The ecological morphology of some alpine plants.** An interpretation of certain structural features of alpine shrubs.

Work was started in November 1919. Paper ready for publication.

Assigned to C. C. Forsaith.

Forest Policy

358. **A study of forest policy.** To analyze and classify the efforts of the United States and the States to establish forest policies, to bring about a better understanding of fundamental principles and more uniform legislation in as far as such a study would tend to forward those objects.

Begun in 1906; outline printed for class used in 1907; the extended study is in manuscript.

Manuscript to be reviewed and published in 1920. The principal place of work is at Greensboro, Ga., but it is expected that a part of the work will be done at Syracuse, N. Y., New Haven, Conn., and Washinton, D. C.

Assigned to Courtland S. Winn and Alfred Akerman.

Experiments in Kiln Drying of Lumber

359. **The kiln drying of yellow birch.** Experiments to determine suitable condition of temperature, humidity, and circulation for the drying of this species, with special reference to the time consumed in drying, the amount of steaming, its frequency and effect on the lumber. Supplementing this work, will be investigations on the steam penetration, coloration of sapwood, per cents of shrinkage, methods of piling and their relation to speed of drying, etc.

Steaming and coloration experiments were started in 1918–19 by R. J. Hoyle. Kiln drying work now under way.

Similar work will be undertaken with maple, beech and other hardwoods native to New York State.

Assigned to H. L. Henderson.

Department of Forest Entomology

360. **Studies of the successions of insect forms bred from dying, dead and decaying hickory.**

Work begun during summer of 1915 and carried on during the past three years in field and insectary. Field data completed and MS well under way.

Assigned to W. W. Blackman and Harry P. Stage.

361. **Studies of the insects affecting yellow birch, Betula lutea.** Insects affecting (*a*) reproduction, (*b*) seedling, (*c*) sapling and pole stage, (*d*) tree stage (standards and veterans), and (*e*) insects bred from dying, dead and decaying wood.

Field studies in the Adirondacks during summer of 1919. Insects bred from wood and catkins in insectary during winter of 1919–20.

Work to be continued afield during next two years. Insects affecting reproduction to be completed during coming year.

Assigned to Prof. Carl J. Drake.

362. **Ecological studies of the Hemiptera in vicinity of Cranberry Lake, New York.**

Work carried on during one summer. To be completed another summer.

Assigned to Prof. Carl J. Drake.

Land Classification in New York State

363. **Land classification.** The problem involves: (*a*) the determination of criteria for a classification of land, and (*b*) the outlining of a system of land classification applicable to New York State, and the development of methods for surveys and reports, with a general compilation of data.

Study of available literature and collection of data to be commenced this year. Direct field investigation as opportunity permits.

Assigned to O. M. Porter, Department of Forest Engineering.

Forest Zoology

364. **A study of the productiveness of animal crops in forest management.** To estimate the relative productivity and economic importance of annual animal forest crops in forest management.

A statistical and comparative study of the productiveness of forests in fish, game, food, grazing and other annual crops of forest food animals, and the comparative value of financial returns from this source. A preliminary study of meat production has been completed and awaits publication.

It is intended that this investigation be extended to other animal crops than food.

Assigned to Dr. Charles C. Adams.

365. **The ecology of the timber line on Mount Marcy in the Adirondacks.** To determine the conditions of life at the timber line.

A field party equipped with meteorological instruments made records during August 1919, in the vicinity of the timber line on Mount Marcy. The members of the party were Mr. Barrington Moore, Dr. Norman Taylor, Dr. George P. Burns, Dr. Chas. C. Adams and Professor T. L. Hankinson. A report is in preparation on both the vegetation and the animals.

It is planned to continue this investigation.

This is a cooperative investigation conducted by the following organizations and their representatives: Mr. Barrington Moore, President of the Ecological Society of America (in charge); Dr. Norman Taylor, Brooklyn Botanical Garden; Dr. George P. Burns, Vermont Agricultural Experiment Station; and Dr. Charles C. Adams and Professor T. L. Hankinson, representing the Roosevelt Wild Life Forest Experiment Station, of the New York State College of Forestry.

366. **The relation of summer birds to the western Adirondack forest.** To determine the status of birds in the ecology of the Adirondack forest.

A summer (1916) was spent living in the field making observations on the relation of the birds to different kinds and conditions of the forest. A detailed census was made of the density of the population of breeding birds in different kinds of forest. The report on this subject entitled, "The Relation of Summer Birds to the Western Adirondack Forest," has been prepared by Professor P. M. Silloway, and awaits publication.

Similar studies are contemplated in the eastern Adirondacks.

Assigned to Professor P. M. Silloway.

367. **Fish cultural management of a forest park for recreational, educational and food production.**

This investigation has been conducted for two seasons (1918–19) in the Palisades Interstate Park, on the Hudson River. A report entitled "A Preliminary Report on a Fish Cultural Policy for the Palisades Interstate Park" has been published in the Trans. of the Amer. Fisheries Society, Vol. 48, pp. 193–204, 1919, by Chas. C. Adams, T. L. Hankinson, and W. C. Kendall (in cooperation with the U. S. Bureau of Fisheries). Other reports are in preparation.

It is expected that these studies will be extended to all the waters of this 40,000 acre Park.

Assigned to Dr. Chas. C. Adams and Prof. T. L. Hankinson, assisted by Dr. W. C. Kendall (cooperating from the U. S. Bureau of Fisheries) and in cooperation with the Commissioners of the Palisades Interstate Park.

368. **The control of mosquitoes by fish in a forest park.** To determine the extent of mosquito control by fish in a bathing lake in a forest recreational park.

Two months summer field work has been made by Dr. J. Percy Moore for the College, working in cooperation with the Commissioners of the Palisades Interstate Park and the U. S. Bureau of Fisheries. A preliminary report entitled "Suggestions and Recommendations for the Control of Mosquitoes and Blood-Sucking Leeches in the Palisades Interstate Park" has been prepared.

The study will be continued.

Assigned to Dr. J. Percy Moore of the University of Pennsylvania.

369. **The control of blood-sucking leeches in a forest recreational park.** To devise means for reducing the numbers of blood-sucking leeches in a large bathing lake.

Two months of field study and experimentation have outlined the main features of the problem and various means of control are being tested. This investigation is being made by Dr. J. Percy Moore of the University of Pennsylvania, for the College in cooperation with the Commissioners of the Palisades Interstate Park and the U. S. Bureau of Fisheries. A preliminary report has been prepared in connection with the studies in the control of mosquitoes.

The investigation will be continued.

This investigation has been conducted by Dr. J. Percy Moore, of the University of Pennsylvania, our leading authority on leeches.

370. **The water bloom of forest park lakes in relation to recreation and fish culture.**

The field work covered the most important waters of the Palisades Interstate Park. The report is well under way presenting the results of the field work and a summary of the control methods used for blooms, including the influence of chemical methods on the fish.

It is highly desirable that further field studies and experiments be made and this is under consideration.

This problem has been investigated for the College, in cooperation with the Commissioners of the Palisades Interstate Park by Dr. Gilbert M. Smith, of the University of Wisconsin, a specialist on these bloom organisms.

371. **The fish cultural management of Oneida Lake.** To formulate a system of management for large forest lakes, similar to a system of

silvicultural management, in order that forest waters may be made to produce an annual income.

Considerable field survey work has been done on various phases of the problem during the past five years. The food and feeding habits of fish, with special reference to mollusca, have been studied by Frank C. Baker and have been published as a Technical Pub. No. 4, "The Relation of Mollusks to Fish in Oneida Lake," pp. 1–366, 1916. Quantitative studies of the smaller food animals have resulted in a second volume, Technical Pub. No. 9, "The Productivity of Invertebrate Fish Food on the Bottom of Oneida Lake, with Special Reference to Mollusks," pp. 1–264, 1918. These studies have shown the importance of mollusks as fish food. Other phases of the fish problem have been published by Adams and Hankinson as, "Notes on Oneida Lake Fish and Fisheries," Trans. Amer. Fisheries Soc., Vol. 45, pp. 154–169. Studies of the parasitic diseases of the fish have been made, in cooperation with the U. S. Bureau of Fisheries, by Dr. Henry S. Pratt, of Haverford College, which have resulted in a MS. entitled, "Preliminary Report on the Parasitic Fauna of Oneida Lake."

Considerable progress has been made on a general report on "The Ecology and Economics of Oneida Lake Fish," by Charles C. Adams and T. L. Hankinson.

At present the main effort is being made to complete the reports now in preparation.

The general problem has been in charge of Dr. Charles C. Adams.

Specialists who have been working on various phases of the work have been indicated above. This work was begun by the Department of Forest Zoology of the College in 1914, and with the establishment of the Roosevelt Wild Life Forest Experiment Station, in 1919 this work has been continued by this Station, in cooperation with the U. S. Bureau of Fisheries.

BEAVERKILL FARMS, ULSTER COUNTY

Richard H. D. Boerker, Forester, Box 42, Mt. Tremper, N. Y.

372. A qualitative study of Catskill Mountain vegetation.

Begun in 1917. Formations, associations, and species are being determined. About 200 species identified.

Present study to be completed by 1921; will be followed by meterological measurements in the different formations.

373. Reforestation of lands too poor for farm use: Determination of species best suited to different localities.

Begun in 1916. A steep southern exposure was reforested with about 5000 Norway pine furnished by the State Conservation Commission in 1916 (April). Over 99 per cent alive in April, 1919. Making excellent growth. A wet, rocky pasture of about 2 acres was reforested with 3000 Norway spruce furnished by the State about the same date. About 95 per cent alive. Total cost in both cases $10 per acre. A number of minor experiments are being conducted to determine possibility of acclimating western yellow pine, Douglas fir, and Engelmann spruce, all from the Rocky Mountains.

To be continued indefinitely. Growth measurements to be made at 5 year intervals.

374. **Management.** To convert a poor second growth of hardwood sprouts (poplar, maple, birch, oak) into a high forest of spruce or pine. Attempt to be made to harvest material at a profit.

Begun in 1918. Present stand averages about 25 cords per acre of trees 1″–6″ in diameter, with two or three larger trees per acre. Area of about 3 acres (mostly poplar) has been cleared and poplar disposed of at a profit. Reforestation in fall of 1919 with Norway spruce.

To be continued. Sale of wood expected to cover all costs, including reforestation. About 150 acres can be treated in this way. Object of this and other projects is to build up a profitable farm forest on a continuous yield basis.

PENNSYLVANIA

PENNSYLVANIA DEPARTMENT OF FORESTRY

Gifford Pinchot, Commissioner of Forestry, Division of Forest Investigations,

J. S. Illick, in charge, Harrisburg

General

375. **Pitch pine in Pennsylvania.** To study characteristics and occurrence, prepare reliable growth, yield, and volume tables, enumerate chief enemies, state local silvical peculiarities, determine quality of the wood, list the uses of the wood, and predict possibilities as a timber tree of the State.

Investigation begun in 1912. Special attention given to the study since spring of 1918. Field of work throughout the State, but especially about Mont Alto, Clearfield, Snowshoe, Bedford, and the Pocono region.

Field work almost completed. Report in preparation.

376. **Chestnut oak in Pennsylvania.** To study range and occurrence prepare accurate growth, yield, and volume tables, ascertain principal silvical characteristics, find out extent to which it is naturally replacing chestnut, and determine successful methods of artificial propagation.

Begun in 1906. Preliminary discussion in reports of Pennsylvania Department of Forestry.

To be continued. Study should be completed within a year.

377. **Basket willow culture.** To increase the production of home-grown rods for basket making, and to bring into use land not now used for any other purpose.

Many experimental holts established on State forests. First production of commercial rods in 1918 from earliest plantings. Investigations at Mont Alto, Caledonia, Pine Grove, Greenwood, Lancaster Valley, Nittany, Grays Run, Ligonier, and Buchanan.

To induce private owners to bring cold, wet, and neglected land into this kind of cultivation. To stimulate basket making by inmates of charitable and penal institutions, and to establish this industry in private homes. To use the areas proposed to be planted on State forests as an object lesson to start the industry generally.

378. **Forest tree distribution.** To ascertain the distribution of the native forest trees of the State; to obtain fuller data concerning their occurrence and their silvical characteristics; to determine the closeness of the correlation between the site factors and the silvical requirements of each species.

Begun in 1895. Systematic plan of procedure outlined in 1912. Collection of data almost complete. General report on the distribution included in Pennsylvania Department of Forestry, Bulletin 11, "Pennsylvania Trees," by J. S. Illick, 1914.

It is planned to publish a bulletin containing outline maps showing the distribution within the State of all the native trees and a discussion of the important silvical peculiarities.

Seeding

379. **Direct seeding.** To determine the possibilities of direct seeding of incompletely stocked forest areas.

Begun in 1902. Continued intermittently to date on selected State forests in various parts of the State. Spot planting and broadcasting have been tried. Species used were: black walnut, pignut hickory, red oak, white oak, chestnut, wild black cherry, sugar maple, basswood, white pine, pitch pine, red pine, Douglas fir, Scotch pine, and Norway spruce.

To be continued.

380. **Source of seed supply.** To ascertain the influence of locality upon the quality of the seed, and the transmission of characteristics through the seed.

Experiment begun in 1910 with Pacific Coast and Rocky Mountain varieties of Douglas fir. Repeated in 1919. Also began experiment with western yellow pine seed from California and Colorado. Also scotch pine from Finland, Riga district, and Germany.

To be continued and extended to cover more species.

Planting

381. **Planting of native hardwood species.** To ascertain the best and most economical methods of establishing and developing stands of native hardwood species on specified sites.

Begun in 1899. Plantings scattered over numerous State forests. The following tabulation gives the total number of each species planted to date (January 1, 1919) and the year when the first plantation of each species was established:

Species.	Number Planted.	Year of Earliest Planting.
Red oak	395,927	1910
White ash	381,733	1905
Honey locust	103,610	1907
Sugar maple	99,114	1910
Wild black cherry	64,340	1910
Black walnut	63,034	1906
American elm	56,382	1909
White oak	33,550	1905
Carolina poplar	25,945	1899
Black locust	10,900	1904
Rock oak	3,350	1905
Chestnut	3,000	1905
Shellbark hickory	2,950	1907

To be continued on a much larger scale than in the past.

382. **Planting of native coniferous species.** To ascertain the best and most economical methods of establishing and developing stands of native coniferous species on specified sites.

Begun in 1902. White, red, and pitch pines are the principal species used. Work conducted on State forests in all parts of the State. The following tabulations gives the total number of trees of each species planted to date (January 1, 1919) and the year when the first plantation of each species was established:

Species.	Number Planted.	Year of Earliest Planting.
White pine	20,669,172	1902
Red pine	1,058,717	1913
Pitch pine	1,638,706	1911

Continuous.

383. Introduction of exotic forest trees. To experiment with exotic species in order to ascertain their growth and yield, and to increase our knowledge of their silvical characteristics.

Work conducted in all parts of the State. The species which have been planted are listed in the following tabulation, which gives the total number set out and the year when the first plantation of each species was established:

Species.	Number Planted.	Year of Earliest Planting.
Norway spruce	4,915,563	1908
Scotch pine	2,971,909	1909
European larch	712,592	1909
Douglas fir	104,566	1914
Western white pine	33,688	1913
Japanese larch	32,500	1917
Western yellow pine	21,985	1908

in addition to the foregoing the following have been set out in small quantities: white spruce, Riga Scotch pine, Finnish Scotch pine, Siberian larch, Chinese arborvitae, Japanese red pine, Japanese black pine, and Himalayan white pine. Twenty-five additional species were planted in spring of 1919.

Continuing.

384. Spacing of seedlings and transplants. To determine the best spacing distance for each species in terms of the locality and the existing vegetation.

Plantations have been established in which the spacing ranges from 3 x 3 feet to 12 x 12 feet. The oldest was established in 1902. Conclusive results will be available in a few years. Work conducted on representative State forests.

To study the established plantation, report their results, and lay out additional plots if necessary.

385. Forest tree planting methods and technique. To ascertain the best and most economical method of planting on specified sites; to make a comparative study of planting tools; to decide upon the most efficient method of organizing planting crews; to determine the cost of planting.

Begun in 1899. Large amounts of reliable data have been collected. General reports have been published. Work conducted on all State forests.

Continuous.

386. Fall versus spring planting. To determine the advantages and disadvantages of fall planting of forest trees.

Begun in 1907. Continued intermittently since then. Comprehensive study laid out in fall of 1918, when six different species (1,000 seedlings each) were planted on six different forests, on five different planting dates at intervals of two weeks. This experiment comprises 24 separate plantations, covers 67.1 acres, has required 141,235 trees, and cost $1,090.37.

387. Classification of seedlings and transplants. To determine a satisfactory method of classifying nursery stock prior to shipment, using age, size, weight, volume, and stockiness as determining factors.

In progress for several years, but more intensively studied during spring of 1919. Work conducted at Asaph, Clearfield, Greenwood, and Mont Alto nurseries.

388. Age of planting stock. To determine the age at which small forest tree seedlings may be set out satisfactorily on various planting sites.

During the past ten years numerous experiments have been established using 1, 2, 3, and 4-year seedlings. Work conducted on nearly all of the State forests.

389. Seedlings versus transplants. To determine the comparative advantages of seedlings and transplants on specific planting sites.

Experimental plots have been laid out on about 25 state forests beginning with 1902.

Nursery Practice

390. Nursery fertilizer experiment. To determine satisfactory kinds and combinations of commercial fertilizers and the proper time to use them in forest tree nurseries.

Begun in 1907. Experiments laid out on a large scale in spring of 1913. Results recorded in 1914–15 report of Pennsylvania Department of Forestry. Additional applications of fertilizer in spring of 1919. Work conducted at Mont Alto, Greenwood, and Asaph nurseries.

To make a more intensive study of the kinds which heretofore gave favorable results.

391. Winter storage of nursery stock. To determine satisfactory methods of storing nursery stock out-of-doors, and in storage buildings and cellars.

Experiments with out-of-door methods have been in progress for several years in four of the large State nurseries.

Construction of storage buildings to hold about one million trees.

Silvicultural Systems

392. Forest conversion methods. To make a comparative study of the different methods of converting inferior hardwood stands into coniferous stands of fine quality.

Many experimental plots have been established on representative and scattered State forests throughout the State covering the method of treating planting sites before the planting operations, and the methods used after the planting is completed. The investigation covers the intentional burning and plowing of planting sites, and the clear-cutting, partial cutting, and girdling of existing hardwood growth. Cuttings may be basal, waist high, or top-lopping. Preliminary report published.

To be continued.

Forest Protection

393. **Forest fire fighting equipment and technique.** To determine the best methods and the most satisfactory equipment to use in extinguishing forest fires in different parts of the State.

Many different tools have been devised and numerous methods of extinction employed. Preliminary reports thereon have been published.

To be continued. Progress reports will be issued.

394. **Assessment of fire damage.** To determine a satisfactory and correct method of assessing damage done by forest fires in immature and mature stands. Special consideration given to damage of soil, humus, regeneration, and the loss of increment.

Plan for field work fully outlined.

395. **Forest fire hazard survey.** To prepare a map of Pennsylvania showing the location of all forest areas, particularly those needing immediate and constant protection. Map will serve as a basis for locating forest fire wardens and patrolmen, and for plans to eliminate hazards.

Field work has been in progress since 1915.

Project to be continued and reported on by counties.

Forest Mensuration and Forest Organization

396. **Subdivision of forests into working units.** To ascertain the best and most practical methods of subdividing forests into working and treatment units.

Begun in 1913. Work interrupted during the war. Subdivision work on one forest completed. Work conducted on Barree, Nittany, Mont Alto, and other State forests.

Work will be resumed in 1919.

397. **Permanent sample plots.** To make an intensive study of carefully selected plots in order to determine the quantitative and qualitative growth of stands, the interrelation of various forms of vegetation, and the correlation of soil and species, to ascertain data for the preparation of stand, age-class, site-quality, and growing stock maps.

Large number of plots have been established. Additional ones are established annually.

Continuous.

398. **Growth studies.** To ascertain the juvenile growth and development of all the native and introduced species occurring in pure and mixed plantations.

Several hundred permanently demarcated plots have been established and the growth existing thereon recorded on special forms. Work conducted on each of the 52 State forests.

Continuous.

399. **Growth acceleration by subsoil dynamiting.** To determine the effect of sub-soil dynamiting on the growth of different species of forest trees in plantations.

Treated areas of one acre each and an accompanying check area laid out between September 27, 1911, and October 14, 1911, on each of the following State forests, Mont Alto, Grays Run, Stone, Wetham, Stuart and Minisink.

Forest Utilization

400. **Stave production.** To determine an economical method of manufacturing staves from blighted chestnut trees, and to ascertain the yield of staves per unit of volume and per acre.

Operation in progress since 1918 on Buchanan State Forest. Preliminary report ready.

To be continued on Buchanan Forest and extended to other forests.

PENNSYLVANIA STATE FOREST ACADEMY

E. A. Ziegler, Director, Mont Alto, Pa.

(Forest investigations on the Mont Alto State Forest and Nursery; now under the general control and coordination of the Division of Silviculture and Investigation, Department of Forestry, Harrisburg.)

Silviculture and Silvics

401. **Permanent sample plots.** To obtain accurate quantitative and qualitative data on growth and yield of mixed hardwood and coniferous stands; to determine site quality on basis of productive capacity, and subordinate vegetation serving as site indicators.

Established annually from 1912 to 1916, Mont Alto State Forest.

Continuous. Measurement each five years. Pure chestnut and mixed chestnut and oak plots injured by chestnut blight to be continued as a study of species naturally replacing chestnut.

402. **Method of establishing sample plots.** To determine an accurate and economical method of locating representative areas suitable for sample plot purposes.

Mont Alto State Forest field work completed. Report in preparation.

403. **Effect of different grades of thinnings.** To determine influence of light, medium, and heavy thinnings upon the remaining trees and to ascertain the consequent stimulation of the growth on the forest floor. Thinnings repeated at various intervals and applied to different aged material.

In progress since 1905. Additional areas treated annually. Control on many plots containing chestnut destroyed by advent of chestnut blight.

Continuous.

404. **Growth study.** To secure reliable data concerning the growth of some important timber trees by means of accurate tree analyses.

Begun in an intensive and systematic form in 1915 on the Mont Alto State Forest. Species studied: White pine, hemlock, pitch pine, table mountain pine, Jersey or scrub pine, chestnut, white oak, rock oak, scarlet oak, black birch, and tulip tree.

Continuous.

405. **Forest conversion methods.** To ascertain a method of converting the hardwood sprout forests into coniferous high forests, which is silviculturally satisfactory and economically recommendable.

In progress since 1910 on the Mont Alto State Forest. Numerous experimental plantings have been made and considerable acreage has been variously treated. Some preliminary results published.

406. Growth studies. To ascertain the juvenile growth of some of the most important timber trees in pure and mixed plantations.

In progress since 1913, covering numerous plantations established since 1902. Species studied: White pine, western yellow pine, Scotch pine, Norway spruce, European larch, white ash, eastern catalpa, white oak, rock oak, chestnut, black walnut.

Continuous.

407. Phenological growth studies. To determine the factors of growth and their relative influence. To ascertain *when* the important timber trees begin growth in spring, *when* their growth ceases, and how it progresses during the active period. Study of the periodicity of growth. Application of results to nursery practice, forest planting, improvement cuttings, and lumbering operations.

Begun in 1917 on the Mont Alto State Forest. Daily measurement of selected trees during the grand period of growth. Preliminary report in preparation.

408. Tree distribution. An intensive survey of the occurrence of the native trees of Franklin County, Pennsylvania. Also a systematic correlation of the natural occurrence of the different species and the habitat.

Begun in 1915. Field work almost completed.

Nursery Investigations

409. Experimental nursery practice with exotic and native species. To ascertain the best methods of handling species in the nursery.

Experiments are now under way with the following exotic and native species:

Species.	Experimental work begun.	Probable date of results.
Pinus montana (European Mtn. pine)	1916	1921
P. densiflora (Japanese red pine)	1916	1921
P. thunbergii (Japanese black pine)	1916	1921
P. koreensis (Korean pine)	1918	1922
P. edulis (western pinyon pine)	1918	1922
P. ponderosa (western yellow pine)	1917	1921
Juniperus virginiana (eastern red cedar)	1917	1922
Celtis occidentalis (hackberry)	1917	1922
Liriodendron tulipifera (tulip poplar)	1917	1922
Liquidambar styraciflua (red or sweet gum)	1917	1922
Diospyros virginiana (persimmon)	1917	1922

It is planned to begin this spring experimental work, as above outlined, with the below listed species, each of which should be under observation in the nursery for about five years:

Cryptomeria japonica—Japanese cedar.
Gingko biloba—Chinese gingko.
Cedrus libani—Cedar of Lebanon.
Picea sitchensis—Sitka spruce or tide-land spruce.
Pseudotsuga taxifolia—Douglas fir (both green and gray forms).
Picea engelmanni—Engelmann spruce.

Abies concolor—Western balsam or white fir.

There are also under observation in the nursery arboretum the following exotic species, most of which were received from the Bureau of Plant Industry, U. S. Department of Agriculture:

Pinus excelsa—Himalayan white pine.
P. pentaphylla—Five leaf pine.
P. pyrenaica—Pyrenean pine.
Abies nordmanni—Nordmann's fir.
Salix babylonica—Chinese form.
S. vitellina—Russian golden willow.
S. viminalis—from Madeira Isles—Mountain osier.
Four (4) *Salix* species introduced from China and Russia.
Populus balsamifera, var. Wobstii—Russian balsam poplar.
P. sauvolens—A mountain poplar of China.
P. laurifolia—White barked poplar.
P. simonii var fastigata—Chinese small-leaved poplar.
P. sinensis—Crimean poplar.
P. brevifolia—Chinese short leaf poplar.
Five (5) *Populus* species from China and South Europe.
Ulmus pumila—Hardy Chinese elm.
U. parvifolia—Chinese small-leaf elm.
Acer truncatum—A Chinese maple.
A. buergeranium.
Juglans—Species from China.
Liquidambar formosana—Chinese sweet gum.
Castanea pumila X crenata—Hybrid of American chinkapin and Japanese chestnut (resistant to blight).
Juniperus chinensis—Chinese juniper.

It is proposed to distribute stock of these species among State forests in different sections of the State, so as to get information upon their frost-hardiness, soil and moisture requirements, possibilities in connection with extending their range in Pennsylvania, general forestal and ornamental significance, etc. To get definite results of real value along these lines will take five years or more in practically every case.

Seedling exposure experiments with various species and under differing weather conditions should be resumed again in the nursery as soon as the time becomes available, and student investigations resume their pre-war status.

410. Experimental nursery practice with exotic and native species. The use of charcoal braize as a soil amendment to bring the stiff clay soil to favorable physical condition has probably passed the experimental stage in the Mont Alto Nursery; yet some studies are still advisable to determine the optimum application. Norway spruce begins to suffer already in some parts of the nursery where charcoal has been most heavily used, showing that the soil is too dark and warm for this species.

Utilization and Mensuration

411. Portable mill scale study. To compare the actual mill cut with the different methods of scaling; to ascertain the mill factor of different species; to determine the proportion of the different grades of products and the percentage of waste; to build up local volume tables for subsequent use in timber estimating.

Work conducted on Caledonia and Mont Alto State Forests. Species studied: White pine, pitch pine, hemlock, red oak, scarlet oak, and chestnut.

Continuation of study and extension to other important species.

412. **Lath production.** To ascertain the quantity and quality of lath obtainable from the slabwood produced by a portable sawmill per thousand board feet of lumber and per cord of slabwood.

Work conducted on Mont Alto State Forest. Species studied: White pine, pitch pine, chestnut, and hemlock.

To be continued. About one-fourth complete.

413. **Production and yield of chestnut shingles.** To ascertain the most economical method of producing chestnut shingles; to determine the yield of shingles per cubic foot and cord; to prepare a yield table giving the number of standard shingles per tree classified according to diameter breast high and used length.

Mont Alto State Forest. Field work completed. Report being prepared.

Management and Organization

414. **Subdivision of forest into working units.** The subdivision of forest properties into units of working (compartments) and units of treatment (lots). In progress since 1913 on the Mont Alto State Forest. Will be continued until entire forest of 22,000 acres has been organized on a continuous yield basis.

415. **Stand differentiation.** To segregate the stands of a forest for the purpose of making a stand map which will serve as a basis for stand descriptions, formation of lots, a complete stock survey, and yield computation.

Has been in progress on a small scale since 1916, Mont Alto State Forest.

Will be continued until all the stands on the forest have been differentiated.

Pathology

416. **Forest tree disease survey.** Preparation of check-list of all forest tree diseases in the vicinity of Mont Alto.

Begun in 1913. Preliminary list complete.

To be continued.

NEW JERSEY

STATE OF NEW JERSEY

Department of Conservation and Development, Division of Forestry, Alfred Gaskill, State Forester, Trenton, N. J.

C. P. Wilber, State Firewarden, Trenton, N. J.

(Assignment: Projects on State Forests are conducted by Forest Rangers or Assistant Foresters under supervision of the State Forester. Other projects are conducted by Assistant Foresters under supervision of the State Forester.)

Silvicultural Management

417. **Forest planting.** To determine the most practical species for planting on the various types of soils and exposures and the practicability of planting as forest enterprise.

Forest planting was begun in 1907 and has continued up to the present: (*a*) on State Forest land, chiefly for experimental and demonstration purposes; to date approximately 50 acres have been planted; and (*b*) cooperatively on properties of private and public individuals and organizations, chiefly as commercial enterprise, although also having experimental and demonstration value; to date over 1,600 acres have been planted.

Plantations will be extended, both on State Forests and on private and quasi-public lands, according to the policy above outlined. (Forest planting is unnecessary on most of New Jersey forest land because natural reproduction is usually adequate, and is recommended only on non-arable lands unwisely cleared for agriculture, or where fire has killed all reproduction. Furthermore, planting is not justified until protection is assured.)

Intermediate Cuttings

418. **Cleanings.** To determine the species which may be left to best advantage and the effect of the cleaning on subsequent growth.

Very little done yet except incidentally in connection with other sorts of cuttings.

Work will be commenced during 1920 on State Forests.

419. **Thinnings.** To determine and demonstrate increased growth and enhanced quality in thinned stands.

Thinnings were made on State Forests from 1908 to 1912 and subsequently records have been kept of results. Since 1907 thinnings have been made on private lands by individuals and organizations cooperating with the State Forester. Records have been kept in many cases.

Work will be continued and extended both on State Forest and lands of cooperators. Records will be kept.

420. **Improvement cuttings.** To demonstrate the value of proper cutting of woodlands.

Improvement cuttings have been made on State Forests and on privately owned lands, especially where work has demonstration value.

This work will be continued and extended, both on State Forests and cooperatively on private lands.

Growth Studies

421. **Quality and volume growth.** To determine quality and volume growth of timber in natural, thinned, improved, planted and burned-over (periodically and intermittently) and unburned stands; the growth of individuals and of stands.

Some data collected intermittently since 1907, but in 1919 a definite program was initiated for collecting such data on State Forests, and elsewhere when practicable.

Work will be continued and extended as opportunity offers, both on State Forests and on private land where cooperation is being carried on.

Protection

422. **Effect of systematic burning.** To determine the effect of absolute protection as compared with controlled periodic burning, controlled annual burning, and uncontrolled intermittent burning, on the growth and quality of species, stands and soils.

Not yet started.

Work will be commenced on State Forests in South Jersey during 1920.

Special Investigations

423. **Tree diseases and insects.** To determine the extent and importance of injury, its causes and control.

Sporadic unrelated investigations as conditions demand or permit in cooperation with State Entomologist and State Pathologist.

This cooperative arrangement, and the policy of watchfulness will be continued.

424. **Land clearing.** To determine methods of killing trees or stumps on land to be cleared to prevent sprouting, and to permit of easier removal.

Sample plots of growing trees, recently cut-over land, and young sprout growth were selected on State Forests, State Experiment Station and on private lands; and treated with various amounts of salt, sulphur, and arsenic solution. Commenced in 1919, cooperating with State Experiment Station.

Data will be collected from the work commenced, and if practicable, further experiments will be continued and extended.

425. **Utilization.** To determine new and better uses for native and planted species.

Not much has been done as yet, except upon occasional requests for assistance from cooperators.

Work will be continued and extended in connection with market studies and cooperation. Wood users will be encouraged to test out new species.

MARYLAND

MARYLAND STATE BOARD OF FORESTRY

F. W. Besley, State Forester, Baltimore, Md.

426. **Utilization of Maryland trees.** Field study of the important species, particularly loblolly pine, in relation to their various uses.

Last summer about 100 sample plots were measured for yield tables, in various even aged, fully-stocked stands of loblolly pine, and several hundred taper measurements were made.

Taper curves to be prepared, resulting in volume tables of different kinds. Logging and mill studies to be conducted both in pine and hardwood to determine costs of various products from the tree to the manufactured state.

427. **Use of loblolly pine for mine props.**

Different-sized sticks weighed by means of a large crane-scale, to correlate DBH and height with weight. This investigation is important in southeastern Maryland, where props are sold in large sticks by the ton.

428. **Deadening.** To determine the most effective means of deadening trees.

Experiments conducted with different species and sizes of trees, using ordinary methods of girdling, a blow torch, and poisons.

429. **Forest taxation.** To collect data as a basis for revising the Maryland tax laws relating to woodland.

Investigation of the present methods of taxing woodlands in the various counties of the State and the effect upon timber production.

430. **Natural regeneration of loblolly pine.** To determine best method of securing natural regeneration of loblolly pine after logging.

Plots have been established where the seed bed was prepared by burning after logging off all but selected seed trees.

On selected plots, seed bed to be prepared with spring tooth cultivator prior to logging.

431. **Removal of litter.** To determine effect of removal of pine needles from forest floor, upon growth of loblolly pine.

Plots have been established in stands where soil cover has been undisturbed. From certain of these the pine needles will be removed at regular intervals.

Periodic measurements to be made in the undisturbed plots, as also in the plots where pine needle cover has been removed.

SOUTH ATLANTIC STATES

NORTH CAROLINA

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

J. S. Holmes, State Forester, Chapel Hill, N. C.

432. **Regeneration of cut-over longleaf pine areas in the Sandhills region of North Carolina.** To show the most practical method of reseeding longleaf and find out whether some other species will not be more satisfactory for reseeding such areas.

Work begun on Sandhills State Forest, Hoke County, in 1916. A number of seed plots sown in that and each succeeding year. Longleaf, loblolly, shortleaf, slash, and maritime pines are being tried. A number of seed beds were started in the spring of 1919, some under lath covers and some in the open. Mice and other vermin have destroyed practically all of these seedings.

Observations on present plots will be made from time to time and any promising results carefully noted and possibly published. Further seedings will be made, and it is hoped later that plantings can be undertaken.

Experiments on Sandhills State Forest are under direct charge of State Forester, who visits the area several times a year.

433. **Artificial regeneration of cut-over and burned-over spruce type in the high mountains of North Carolina.** To determine the best species and the most effective methods of seeding and planting.

Work begun on Mt. Mitchell State Park (elevation over 6,000 feet) spring of 1918. A number of seed plots sown in different locations with seed of red spruce, Norway spruce, hemlock, and locally collected Fraser fir. A small experimental nursery has also been started.

Examinations will be made of present plots and seedings made of other species, especially white pine. Plantings will be made from time to time of promising species, and also Fraser fir and spruce coming up naturally in the uncut forests.

Seed plot experiments on Mt. Mitchell State Park have been conducted by D. L. Moser, Black Mountain, N. C., who is in charge of the Park and resides upon it. State Forester directs and supervises work.

NORTH CENTRAL STATES

OHIO

OHIO AGRICULTURAL EXPERIMENT STATION

Department of Forestry, Edmund Secrest, Chief, Wooster, Ohio

Silviculture

434. **Soil fertility experiments in the propagation of forest planting stock.** To determine the kinds, quantities, and combinations of different fertilizers for production of nursery stock.

Work begun in 1916 in white pine seed beds. Continued on white ash, white pine, and catalpa in 1918.

These experiments will be extended to other species.

435. **Forest arboretums.** To determine adaptation of species to different soil conditions, to determine species adapted for mixtures in plantations, spacing distances, and degree and frequency of thinnings.

Work begun 1906 with native and exotic species. Successive plantations have been established each year.

To be continued as conditions warrant.

436. **Tree studies.** Studies of commercial tree species with reference to silvical characteristics and utilization.

Field work on the white ash completed and data have been compiled. Partial data on white, black, red, scarlet, and chestnut oak secured.

Studies to be extended to other species.

437. **Natural regeneration studies.** Extent of woodland grazing and effects upon reproduction. Influences affecting the composition of the reproduction on different forest types.

Begun in 1908.

To be continued.

438. **Forest survey.** Detailed surveys by counties.

Begun in 1907. Bulletin No. 204- No. 211, Ohio Experiment Station.

To be continued.

Forest Products

439. **Timber markets and marketing conditions in Ohio.** Distribution of commercial timber by species.

Begun 1916. Preliminary report. Bulletin 302, Ohio Experiment Station. Report in press.

To be continued.

440. **Durability of farm timbers.**

Bulletin No. 219 and Monthly-Bulletin for March, 1919, Ohio Experiment Station.

To be continued.

INDIANA

STATE BOARD OF FORESTRY

Chas. C. Deam, State Forester, Indianapolis, Ind.

441. **Trees and shrubs of Indiana.** To be published as a book, illustrated.

About one-third written.

To be completed in two years.

442. Investigation of the growing of black locust in Indiana.
A continuing project.

443. Studies of growth rate.

PURDUE UNIVERSITY

School of Science, Stanley Coulter, Dean, Lafayette, Ind.

444. Rate of growth of commercial hardwoods under varying ecological conditions.

The areas selected for investigation are forest tracts in which cutting is being done. The ecological factors of the areas are studied intensively. Sections from the trunks of the trees felled are sent to the Laboratory for careful study. The work has been under way for several years.

Assigned to Prof. Coulter, assisted this year in the collection of material by the State Conservation Commission.

445. Natural afforestation of barren lands. To ascertain the factors responsible for the afforestation of an originally barren area in Clark County, Indiana.

This area was fairly well delimited in 1845-50 by Dr. A. M. Clapp, of New Albany. It was originally treeless but surrounded by forests At present the "Barrens" are represented by a heavy young growth of hardwood species.

Under the direction of Prof. Coulter.

ILLINOIS

STATE NATURAL HISTORY SURVEY DIVISION

Stephen A. Forbes, Chief, Urbana, Ill.
R. B. Miller, State Forester, Urbana, Ill.

446. Correlation between different forest types and different types of soil.

The work of correlation is now going on in seven counties. It is based on the admirably exact and detailed work of the Soil Survey of the State, which has been in active operation for the last 17 years.

Reports or partial reports on the seven counties will be published soon in the annual report of the Illinois Academy of Science and later, perhaps, as bulletins of the Natural History Survey.

Assigned to a corps of volunteer workers in cooperation with the State Forester.

447. Forest survey of a county in southern Illinois, probably Union County.

New project.
To be conducted in summer of 1920.

GULF STATES

GEORGIA

COOPERATIVE EXTENSION WORK

Louis A. Zimm, Extension Forester, Athens, Ga.

448. Thinning.

Two projects under way, on which work will probably be done this fall.
Assigned to L. A. Zimm.

449. Coal-tar treatment of sap pine posts.

Six fence post, demonstrations to determine the value of sap pine posts treated with coal tar.

Assigned to L. A. Zimm.

450. Marketing of farm woodland products.

It is proposed to have several demonstrations started by fall.

Assigned to L. A. Zimm.

ALABAMA

GEOLOGICAL SURVEY OF ALABAMA

Roland M. Harper, Botanist, University, Ala.

451. Investigation of all natural resources, including trees and wild plants.

Botanical studies by Dr. Charles Mohr were conducted in the last quarter of the 19th century, culminating in "Plant Life of Alabama," published in 1901. From about 1896 to 1901 some botanical field work was done around Auburn by Prof. F. S. Earle and associates. In 1908 J. H. Foster of the U. S. Forest Service made a reconnaissance of the forests in cooperation with the State, and submitted a manuscript report which has not been published. R. M. Harper began work in Alabama in 1905 as Botanist of the Geological Survey, and has spent about three years, intermittently, visiting every county in the State. Preliminary results in botanical magazines beginning 1906. Part 1 of "Economic Botany of Alabama," a geographical report on forests, was published in 1913 as Monograph 8 of the Survey; abstract appeared in American Forestry, same summer. Supplementary paper entitled "A Forest Census of Alabama by Geographical Divisions," by R. M. Harper, in Proc. Soc. American Foresters, April, 1916, Vol. 11, No. 2, 208–14.

The forests are being studied from the regional and quantitative point of view; *i. e.*, the State is first divided into natural regions, and then the relative abundance and stand of each species estimated. The second part of the Economic Botany, a catalog of the trees and shrubs with their distribution and uses, is well advanced and will be published at the first opportunity.

Assigned to R. M. Harper.

LOUISIANA

DEPARTMENT OF CONSERVATION

R. D. Forbes, Superintendent of Forestry, New Orleans, La.

Forest economics

452. A study of the comparative costs of logging large and small timber as a basis for recommending a diameter limit in logging and thereby securing a measure of forestry practice among the lumber companies.

A preliminary report on this project was made in November, 1919. The data obtained up to that date were significant but not conclusive.

Further data will be collected from time to time.

Under direction of R. D. Forbes.

Silviculture

453. Growth rate of second-growth longleaf pine: to afford yield data as a basis for predicting returns from the practice of forestry.

Plans prepared; proposed to begin field work about July 1, 1920, and to continue it intermittently throughout the year.

Assigned to one or two field men under direction of R. D. Forbes.

454. **Slash pine in the prairie region of southwest Louisiana:** its adaptability, rate of growth, and qualifications as a farm woodland tree.

Two acres of prairie land were seeded on May 1, 1919, to slash pine, one acre broadcasted, and the other seed-spotted with spacings of 6 x 6 and 8 x 8 feet. Seed provided by the U. S. Forest Service.

Plans for future work include simply observations of the results of the planting.

Under direction of R. D. Forbes.

LAKE STATES

MICHIGAN

STATE OF MICHIGAN

Public Domain Commission

Marcus Schaaf, State Forester, Grayling, Mich.

455. **Underplanting.** To determine the success of underplanting in summer and early fall.

Experimental planting is being conducted to determine the success of underplanting during the summer and early fall months. Commencing the first of June and continuing until October, one-half acre is planted each week to 3–0 white pine, 875 per half acre. Planting done in some manner as in spring and fall planting.

456. **Silvical study of Norway and white pines.**

A silvical study of a virgin, even-aged, well stocked stand of Norway and white pine covering 200 acres is being made.

Will be completed in 1919.

457. **Silvical study of jack pine.**

Begun 1919. Study will seek to determine: (*a*) into what site classes jack pine land may be most conveniently divided for the State work, and description of sites for ready recognition; (*b*) rate and habits of growth when pure and when in mixture with other pines and hardwoods; (*c*) number of trees per acre at different ages for optimum growth and thrift; (*d*) the serious injuries to which the species is subjected, and methods of control.

Will be continued for several years.

MICHIGAN AGRICULTURAL COLLEGE

Department of Forestry

A. K. Chittenden, Professor of Forestry, East Lansing, Mich.

458. **Sand dune and drift control.**

(*a*) Drift control: demonstration plantings.

Three demonstration plantings established: (1) Holland Drain Project: Sand blow to be held by forest planting; begun 1916, 4 miles north of Holland. (2) Loss Farm, Muskegon: 20-acre tract moved by wind in 10 years; work begun 1918. (3) Big Prairie: control attempted by Mr. Barton and State; work begun 1918. Forest tree stock supplied by college nursery was planted on all three projects in spring of 1919. Each under direct and personal control of County Agricultural Agents of respective counties. Planting supervised by Field Agent E. C. Mandenberg.

These areas to be kept under observation and data to be secured. Repair planting to hold control of drift sand will be made whenever necessary. Final development into county forests and experimental parks.

Michigan Experiment Station foresters to be in charge of collection of data and plans for future handling as experiment. To cooperate fully with County Agents and owners.

(*b*) Sand dune control and reforestation.

Work not yet started. Plantings planned in three localities: (1) Ocean County, on bad traveling dunes; examination made and plans considered. (2) At Saugatuck: complete plans and specifications have been prepared. (3) Berrien County; plans now being prepared by County Agent Lurkins.

Work on large scale is necessary; to be financed by owner; plans and supervision to be furnished by Station, labor and planting material by owner. It is hoped that a plan of cooperation may be affected, whereby one or more of the larger dune areas may be used for demonstration.

Foresters only to be assigned to cooperation experimental project in reforestation. Cooperation triangular: Owner-Co. Agt. Michigan Experiment Station.

459. **Fall planting.**

A careful test run over a five-year period to determine safety of fall planting, kinds of soil, species, and ages best adapted for Michigan.

Use records that are available and accurate, of plantings already established. Establish new plantings. Full data to be filed on: (1) location, (2) soil, (3) exposure, (4) species and age, (5) method of planting, (6) subsequent care.

Assigned to forest students under supervision of forester.

460. **Diameter, height, and volume growth of forest plantations:** determination for various species planted in Michigan during past 50 years.

Measurements made of (*a*) plantations and second-growth forests and (*b*) highway and shade trees, with reference to influence of spacing, pruning, soil, exposure, and care. Work to be done in all parts of the State in order to be representative of the State as a whole. Field work completed.

Assigned to Forester and student assistants.

461. **Availability of ironwood for ax helves in Michigan, with possible inclusion of sassafras, dogwood, juneberry, etc.**

Study is aimed to tell whether there will be a future, and the localities involved.

Careful estimates to determine feasibility of utilizing ironwood, to be made in representative areas in each county in a district.

462. **Utilization of minor species for special purposes, with particular reference to seasoning.**

It is proposed to determine the best uses for little-used species which grow as understory trees: ironwood, dogwood, blue beech, sassafras, juneberry. Special studies in kiln work and in close technical tests.

Work to be done at the college; to include methods of air and water seasoning, as well as kiln work. Records to be kept and results published. If supply warrants, effort to be made to bring about utilization of species suited.

463. **Maple sirup study.** Study of flow of sap as influenced by number of tapholes; fuel costs, etc.
Begun in 1916. Partial results published from time to time.

UNIVERSITY OF MICHIGAN

Department of Forestry, Filibert Roth, Professor of Forestry, Ann Arbor, Mich.

464. **Planting.** Methods and spacing.
The species and date of starting are as follows:
Scotch pine—1904, '06.
Austrian pine—1904, '06.
White pine—1904, '07, '15.
Douglas fir—1904.
Yellow poplar—1904.
Catalpa—1904, '15.
Norway spruce—1904, '11, '15.
Black locust—1904, '06.
White ash—1906, '08, '19.
Red oak—1906, '07, '08, '15.
White oak—1906.
Black walnut—1906, '09.
Hickory—1906.
Osage orange—1905.
Western yellow pine—1906, '08, '09, '12, '15.
Russian mulberry—1906.
Box elder—1906.
Basswood—1906.
White elm—1906.
Sugar maple—1906.
Chestnut—1907.
Cottonwood—1912.
Norway pine—1919.
In charge of forestry faculty, with student assistance.

465. **Thinning.**
The dates of thinning are as follows:
Black locust—1914.
Scotch pine—1915, '19.
White pine—1915.
Austrian pine—1919.
Western yellow pine—1919.
White elm—1918.
White ash—1919.
All thinnings are repeated at five-year intervals.
In charge of forestry faculty, with student assistance.

466. **Coppice reproduction.**
Catalpa—1911, '15.
In charge of forestry faculty with student assistance.

467. **Selection cutting.**
Mixed hardwoods—1917, '18, '19.

These cuttings are repeated on each compartment every ten years, the results upon growth and reproduction being studied by permanent sample plots.

In charge of forestry faculty, with student assistance.

468. Growth study.

Conducted by measurements of all plantations at five-year intervals, treating each one as a permanent sample plot.

In charge of forestry faculty, with student assistance.

MINNESOTA

UNIVERSITY OF MINNESOTA

Division of Forestry, E. G. Cheyney, Director, Univ. Farm, St. Paul, Minn.

Experiment Station, W. H. Kenety, Cloquet, Minn.

Sowing and Planting

469. Tests of species.

The tests of species from other parts of this country and from the Bureau of Foreign Seed and Plant Introduction have been continued. Several promise to have special merit for Minnesota, one species of poplar from Russia showing exceptional promise.

Assigned to W. H. Kenety.

470. Comparison of different classes of stock.

Now includes over 400 half-acre plots. Last year 20 half-acre plots were planted with jack pine and Scotch pine, which completed the planting in this experiment with different classes of stock in different situations. Counts and measurements of about 200 one-acre plots were made when the fires occurred.

Counts and measurements will have to be made for many years to come. Field plots to be laid out on the State forests in the northeastern part of the State to determine best methods and stock for reforestation of the types of land found in the new State forests.

Assigned to W. H. Kenety.

471. Seasons for sowing and planting.

Work practically completed. Results relating to nursery work have been written up and included in the report of the Station.

Work will have to be continued to secure average results over a number of years.

Assigned to W. H. Kenety.

472. Effects of cover under planting.

Experiments now include about 150 plots. Work on effects of cover and stock best suited to replace jack pine finished as far as planting is concerned.

Plots to be measured yearly.

Assigned to W. H. Kenety.

473. Study of site factors.

In 1918, three years' work had been completed at the Station. The moisture equivalent determinations for white spruce are fairly complete. Data have been secured for most of the commercial species, though they are far from complete.

Assigned to W. H. Kenety.

Nursery Practice

474. Methods and factors.

The work has been completed in part and results published in the report of the Station. Work on fertilizing, spacing, and damping off not completed. In 1918 nursery studies were continued for white spruce, but no satisfactory methods have as yet been found to make success certain with this species.

Intensive experiments in progress on fertilizers for seed beds and transplant beds.

Assigned to W. H. Kenety.

475. Damping-off of coniferous seedlings.

Work continued in 1918 on white spruce, but results are not satisfactory. The results of the work previously done are now compiled and with the completion of this year's work will be ready for publication. Very intensive experiments are under way to complete the work this year. This will mean the planting and counting of 70 beds and will take the full time of three men.

It is expected to finish this work this year.

Assigned to W. H. Kenety and E. M. Freeman.

Seed Studies

476. Collection, treatment and characteristics of forest tree seeds.

Work on seed collection, extraction, and cleaning was conducted in 1918 for balsam fir and white cedar. Work completed for white spruce and Norway pine, fairly complete for white pine and jack pine. Some results have been secured on source of seed in relation to hardiness and immunity to insect and disease attacks.

Assigned to W. H. Kenety.

Management

477. Natural reproduction from seed trees.

Plots have been laid out in areas where seed trees have been left and where cutting was made during and immediately after a good seed year.

Plots to be recounted this year.

Assigned to W. H. Kenety.

478. Effects of thinnings.

Thinnings and check plots have been made in three different densities and ages of jack pine, and Norway pine; these were remeasured in 1918 for height and diameter, the cubic contents have been computed, and the increment determined for the 5-year period.

Thinning plots to be remeasured in 1919. Paper on comparative annual increment and mortality in jack pine and Norway pine to be prepared for publication.

Assigned to W. H. Kenety.

479. Brush burning.

No more work has been done except to render a report to the State Forester.

Proposed to study effect of brush burning in relation to reproduction in the different ranger districts if help and funds become available.

Assigned to W. H Kenety.

480. Working plan for Itasca Park.

Preliminary plan prepared.

When the cutting of private holdings is completed, a definite 10-year planting plan should be prepared, as planting will be the most important forest operation within the Park for many years. Record books in the form of maps and tabulations, so made as to be readily kept up to date, should be prepared.

Assigned to J. H. Allison.

Mensuration

481. Mill scale study of white and Norway pines.

A graded mill scale study of 3000 white and Norway pine logs has been made and the computation completed.

Articles on this study to be prepared for publication.

Assigned to W. H. Kenety.

482. Volume growth and yield of commercial species.

Some data have been secured for nearly all the commercial species, but a special detailed study of each species is badly needed and the data will be added to as quickly as help and funds permit.

Assigned to W. H. Kenety.

483. Sample plot study of volume and yield in Itasca Park.

Sample plots have been established in jack pine and aspen stands, measured, and results tabulated. Rate of growth of 23-year old jack pine to the east of Lakes Mary and Itasca found to be approximately 1 cord per acre per year.

Measurement of additional sample plots in other jack pine and aspen stands—possibly in stands of other species also.

Assigned to J. H. Allison.

484. Grand Rapids growth studies.

Sample plots in planted stands of Norway, jack, and Scotch pine at Grand Rapids sub-station, for study of yield.

Plots to be measured in 1920.

Assigned to J. H. Allison.

Windbreaks and Prairie Plantations

485. Windbreaks and prairie plantations. A mass of material was gathered in 1917 on windbreaks in western Minnesota. Notes have been completed and manuscript finished on trees on Minnesota farms.

Publication postponed for a short time to incorporate material recently secured.

W. H. Kenety.

Wood Preservation

486. Preservative treatment of fence posts. To determine best and most economical treatment of fence posts cut from six species common to farms in Minnesota.

Begun 1909, in cooperation with the United States Forest Service. Part of the 3000 variously treated posts were set in the fences and vineyards at the Fruit Farm, Zumbra Heights. The remainder were sold to farmers living near by. The posts have been inspected annually by the Division of Forestry and biennially by the U. S. Forest Service.

Assigned to J. H. Allison.

487. Effect of structure, time of cutting, and methods of seasoning of white cedar, on the penetration of preservatives. To determine the reason of and remedy for the great variation in penetration of preservatives in cedar poles when treated under uniform conditions.

New project.

Material will be cut in the woods at different times of the year, and seasoned in several different ways in the open air. Rate of growth and structural studies and tests as to permeability will be made.

Assigned to J. P. Wentling.

Studies of Minnesota Woods

488. Wood collection.

Collection of authentic samples of all woods of the United States (especially Minnesota) and preparation of museum blocks of all native woods and sets of authentic specimens for forwarding to various institutions in Minnesota was begun in 1918.

Assigned to J. P. Wentling.

489. Structure, technology, uses, and supply of the common woods of the State.

New project.

Supply and uses to be studied in the field, structure and properties at University Farm.

Assigned to J. P. Wentling.

PRAIRIE STATES

IOWA

IOWA STATE COLLEGE

Department of Forestry, G. B. MacDonald, Professor of Forestry, Ames, Iowa.

490. Timber preservation. To determine most effective means of increasing durability of farm timbers; primarily concerned with native fence post woods and posts commonly used in the State of Iowa.

Preliminary work was started about 1905 when a number of experimental fences were set out. Detailed report on these experiments published in August, 1915, in Bulletin No. 158, Iowa Agricultural Experiment Station.

All experimental fence lines are being continued and will be reported on in detail at intervals of five years. It is also the purpose to extend the experiments by using other preservatives than creosote and also a greater variety of woods.

Experiments were started by H. P. Baker in cooperation with U. S. Forest Service; continued by C. A. Scott 1908–10; now in charge of G. B. MacDonald.

491. Forest planting. To test the value of various native and exotic trees on different sites and soils in Iowa.

Small plantations of the following species have been established and experimental data are being collected; hardy catalpa, Carolina poplar, walnut, white pine and other coniferous species. The project also includes some reforestation experiments on sandy lands adjoining the Mississippi River.

It is the purpose of the Experiment Station to establish additional plantations of various species and keep a record of growth.

Experiments started by C. A. Scott 1908–10; G. B. MacDonald now in charge.

492. **Growth and yield of native and planted trees.** To determine the yield of the more important timber trees in Iowa.

Measurements have been taken covering a large number of plantations of cottonwood, walnut, white pine, and European larch.

It is the purpose of the Experiment Station to supplement these measurements. The growth of additional plantations will be determined and also it is expected to have this work extended to cover native stands.

G. B. MacDonald in charge.

493. **Investigations in forest products.** Principally to determine better methods of marketing Iowa woodlot products.

Some investigations along this line were conducted in cooperation with the U. S. Forest Service. These were published in Experiment Station Bulletin No. 142, in August, 1913, "The Wood-Using Industries of Iowa."

This project will be continued as funds permit.

G. B. MacDonald in charge.

494. **Forest management.** This project includes three sub-projects: Management of native woodlands; effect of grazing on woodlots; and regeneration of planted woodlots. It is the purpose of these investigations to determine a system of forest management for the various timber types of Iowa; the effects of grazing, fire, etc., on the woodlands, and a satisfactory method of regenerating native woodlots or shelterbelts which were planted 30 to 50 years ago for protection.

Circular No. 27, "Renewing the Shelterbelt," published by the Agricultural Experiment Station in 1916.

These investigations will be continued as funds permit.

G. B. MacDonald in charge.

ROCKY MOUNTIAN STATES

IDAHO

UNIVERSITY OF IDAHO

School of Forestry, F. G. Miller, Dean, Moscow, Idaho

495. **Experimental tree planting.** To determine the forest trees adapted for planting in Idaho.

Work begun in 1910. Bulletin 105 of the Idaho Agricultural Experiment Station, "Trees, What, Where, When, and How to Plant," by Shattuck and Cook, published in 1918.

Investigation being continued.

496. **Wood oils for ore flotation.** To determine the practicability of extracting oils from commercial woods of Idaho for use in ore flotation.

Yield in gallons per cord and cost per gallon have been determined for six leading species.

Now awaiting results of tests by School of Mines.

Conducted in cooperation with School of Mines.

497. **Utilization of logged-off lands in Idaho.** To determine the location and area of logged-off lands and what portion of them is chiefly valuable for agriculture, forestry or grazing.

Rough survey now under way.

To be followed by more intensive study later.

Conducted in cooperation with Idaho Experiment Station and Forest Service.

498. **Reconnaissance of State timberland at Big Payette Lake.** To introduce regulated cutting and to develop plan for recreational features of the lake front. Area about 14,000 acres.

Work in progress this summer. Regulated cutting now being practiced on present timber sale area, comprising 2500 acres.

Conducted in cooperation with State Board of Land Commissioners.

499. **Reconnaissance of Hayburn Park, area 8000 acres.** To develop cutting plan for timber, also plan for the recreational facilities of the Park.

Preliminary examination made this summer.

To be followed by reconnaissance study next summer.

Conducted in cooperation with the State Department of Public Works.

500. **Quantitative and qualitative forest increment on cut-over lands.** To determine the amount and character of timber produced upon cut-over lands.

Preliminary plans under way.

To be conducted in cooperation with the Forestry Committee of the National Research Council.

501. **Standardization of Silvicultural practice in the various forest regions of the United States.** To determine the best methods of handling timberlands.

Preliminary plans under way.

To be conducted in cooperation with the Forestry Committee of the National Research Council.

502. **Correlation of biological factors with physical, chemical, and structural qualities of timber.**

Preliminary plans under way.

To be conducted in cooperation with the Forestry Committee of the National Research Council.

503. **Toxicity of pyroligneous acid or its fractions.** To determine the possibility of the utilization of the products of destructive distillation of wood for the preserving of wood.

Preliminary work under way.

504. **Studies in the enzymes of the wood-destroying fungi.** To determine what enzymes are present in the various wood-destroying fungi.

Continuation of former work.

505. **Relative durability of commercial Idaho woods.** To determine the resistance of Idaho woods to decay so that more intelligent utilization can be made.

Work well under way.

COLORADO

COLORADO AGRICULTURAL COLLEGE

Department of Forestry, W. J. Morrill, Professor of Forestry, Fort Collins

506. **Fence post preservation.** Preservative treatment of cheap Rocky Mountain fire-killed post timber.

Posts of lodgepole pine and Engelmann spruce given five, and of alpine fir two different treatments, with local water-gas-coal tar creosote, and with crude petroleum. Control posts untreated, for each species. Records of percentage sound and percentage serviceable after six years placement made in 1918. A second lot of posts, all split cedar (*Thuja plicata*), were placed in ground four years ago after two tank open tank method with water-gas-tar creosote treatment; inspected for first time in 1919.

Experiment to be continued during several years or until practically all the posts have failed.

Assigned to W. J. Morrill.

ARIZONA

CARNEGIE INSTITUTION OF WASHINGTON

Department of Botanical Research Desert Laboratory, Tucson, Ariz.

D. T. MacDougal, Director

507. Measurement of variations in volume of growing trees by the use of the dendrograph.

As a part of a plan for a comprehensive study of growth, the measurement of variations in volume of tree trunks has been undertaken. From a consideration of the records of many other plants and of separate organs showing that in addition to the general march of growth there are daily variations in size, it was found advisable to design an instrument which might be attached to a tree trunk and which would make a complete and continuous record of the diameter or of the circumference. Two general plans for this have been under consideration. In one an encircling wire carried plungers which are in contact with the tree and which serve to communicate changes to the wire which is connected with a recorder. Some results were obtained by an instrument of this kind, but it was found more practical to develop a second type of instrument, in which a rigid yoke constructed of bario, invar, or some metal alloy with a low temperature coefficient, was put in place around the trunk and 1, 2, or 3 contact screws were fitted to the yoke on one side of the tree, while on the other side the bearing end of the lever provided an additional contact. Variations in distance representing the diameter or an approximation of it caused movements of the lever, which were transmitted to the pen arm of the recorder. The recording instrument and the yoke are supported in a suitable manner on a base composed of a belt of hinged wooden blocks around the tree.

Specifically it was proposed to ascertain the variations in the bases of trunks, the bole some distance above the ground, and to extend the measurements to the uppermost part of the trunk.

During 1919 these working models, each slightly different from the others in some part of the mechanical design, have been operating as below, all being attached to the base of the trunk at a distance of about 4 feet from the ground.

One at Baltimore has made a record of an American beech (*Fagus grandifolia*) in the grounds of the Johns Hopkins University since April, under the care of Mr. W. F. Gericke. A second instrument has taken a record of a sycamore (*Platanus occidentalis*) in the Missouri Botanical Garden since April, under the care of Dr. H. von Schrenk. A third instrument was put in place on an Arizona ash (*Fraxinus arizonica*)

14 years old on the grounds of Dr. H. W. Fenner at Tucson, early in March. A fourth was taken up into the Santa Catalina Mountains by pack animals and placed on a Chihuahua pine (*Pinus chihuahuana*) at an elevation of 6000 feet about the first of April. This instrument has been visited weekly by Mr. B. R. Bovee and has made a perfect record. A fifth instrument was attached to a live oak (*Quercus agrifolia*) in the grounds of the Coastal Laboratory at Carmel on February 17 and has made a complete record of the variations in the base of the trunk since that time, the growing season being now closed. A sixth instrument was placed on a Monterey pine (*Pinus radiata*) in March and has worked perfectly since that time. The actual increase for the season is practically terminated.

In addition, various recording devices are in operation in taking the diameter and variations in length of the leaders of small trees and the growth of seedlings of the Monterey pine.

The examination of the records brings to light some very important facts which seem to have been unknown or but little known, in the growth of trees.

The plans for further work are as follows: The experience of the present season is being used in working out an improved design of the instrument of which it is proposed to operate about 25 on various selected species during 1920. Assignments or arrangements with cooperators have not yet been completed, although some correspondence and some conferences have been started with regard to the matter.

Some discussion of the general results this season is being embodied in the Annual Report of this Department, which will be printed and distributed shortly after the first of the year, and possibly the matter will be discussed at some of the winter meetings, although no arrangements have yet been made for doing so.

This project is in charge of local observers under the direction of Dr. MacDougal.

PACIFIC COAST STATES

CALIFORNIA

STATE BOARD OF FORESTRY

G. M. Homans, State Forester, Sacramento

508. Shade and ornamental trees in California. To determine suitable trees in different sections of the State for lawns, residential streets, and highways.

Photographs taken of about 250 typical shade and ornamental trees. Characteristics and habits of these trees are being written up for publication.

Additional photographs will be taken to complete list of illustrations needed for publication.

Assigned to California State Board of Forestry.

509. Planting of shade trees on business streets.

Plane trees planted in heart of business section of Sacramento where basements have been excavated to the curb. Described in Sixth Biennial Report of State Board of Forestry. Trees under observation and photographs taken at intervals to show progress.

Stimulation of planting of various species in city streets. Observation in rates of growth and hardiness of trees under existing conditions.

Assigned to California State Board of Forestry.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE

Division of Forestry, Walter Mulford, Professor of Forestry, Berkeley

Silviculture

510. A study of the development of stands of Bigtree.

Sample plots laid out and trees measured and tagged August, 1915, in stands of bigtree natural reproduction, Whitaker's Forest, Tulare County, California.

To be remeasured at intervals of five years or more.

Assigned to Woodbridge Metcalf.

511. A study of the growth and yield of various species of eucalyptus on different sites in California.

Work begun on some plantations by Forest Service in 1912. Remeasurements made on these and others by W. Metcalf and J. A. Mitchell in 1916. Sample plots now located in groves from Glenn County to San Diego County, California.

Sample plots to be remeasured at about 5-year intervals. Report on work to date being prepared.

Assigned to Woodbridge Metcalf.

512. A study of trees suitable for windbreak planting on various sites in California.

Proposed in 1916. Location of work; portions of Sacramento and San Joaquin valleys, seacoast, and semi-desert areas. To include a general survey of windbreaks in California and their influence on production of various agricultural crops. No work done to date.

Existing windbreaks to be investigated and comparative records made of wind velocity, temperature, and evaporation in shelter of windbreak and on adjacent unprotected areas. Planting plan to be prepared for University Farm, Davis, Calif., to test accuracy of conclusion.

Assigned to Woodbridge Metcalf.

513. Studies in adaptability and rate of growth of trees in the North Sacramento Valley.

Plantations of over 100 species of trees have been set out on the Chico Forestry Station, Butte County, California, beginning in 1889 and continuing at intervals to the present time. Area has been mapped and growth measurements are in progress.

Publication of results as soon as completed. Plantations to be extended to test other species.

Assigned to Woodbridge Metcalf.

514. Studies in adaptability and rate of growth of trees in southern California.

Seventy species of eucalyptus and many other trees have been set out on the Santa Monica Forestry Station, Los Angeles County. Some of these are now 20–30 years old. Measurements are being made as soon as accurate identification can be made. All records were destroyed by fire in 1904.

Publication of results, extension of plantations using new species.

Assigned to Woodbridge Metcalf.

515. Trees suitable for planting without irrigation in the Berkeley Hills, Alameda County.

Begun 1916. Tests have been made with species from Australia, New Zealand, Africa, Japan, and China. Some have been raised from seed in the Berkeley Nursery but many have been received from the Plant Introduction Gardens.

Expensive methods of planting have given good results with several species. It is proposed to select species which will stand cheaper methosd of handling. Work to be extended in experimental planting area in Strawberry Canyon.

Assigned to Woodbridge Metcalf.

Lumbering Studies

516. Factors affecting the cost of log making and skidding.

Begun during 1916, during which field season several men made time studies of donkey and big-wheel logging in both the redwood region and Sierra pine region. Data were taken on felling, marking, limbing, hand bucking, steam saw bucking, and yarding. Each operation is analyzed into its component parts, each of which is timed repeatedly. A large amount of data is at hand but has not been worked on owing to the absence of Captain Bruce.

To be continued according to working plan. It is necessary to secure a mass of data large enough so that for each gradation of one variable in the several steps in log making the others will show a reasonably constant average.

Assigned to Donald Bruce.

Mensuration

517. Preparation of volume tables for principal California species.

An investigation has been made as to a proper diameter and height basis for volume tables and tentative conclusions reached. A study is in progress of the best technique of volume table preparation. Tables are being made in a number of different ways from the same data and their accuracy compared. This phase of the project will be completed this winter. Work is started on the preparation of a new volume table for white fir using all available field measurements gathered by the United States Forest Service, the United States Bureau of Plant Pathology and the University.

After the completion of these steps it is planned to continue the preparation of a set of volume tables for California species.

Assigned to Donald Bruce.

518. Quantitative and qualitative forest increment on cut over lands.

This project was initiated by Mr. Raphael Zon at the direction of the National Research Council.

Tentative plans of work have been drawn up and collaborators are being secured in each State.

A survey of existing data will first be made and a bibliography or summary prepared therefrom. An attempt will be made to standardize the technique of growth studies and to work up a first approximation of the total growth on second growth stands.

Assigned to Donald Bruce.

UNIVERSITY OF CALIFORNIA

Prof. W. L. Jepson, Berkeley

519. Studies on the taxonomy of chaparral species in California.

Independent investigation by Prof. Jepson.

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